Clementine's New Views of the Moon

ASTRONOMY®

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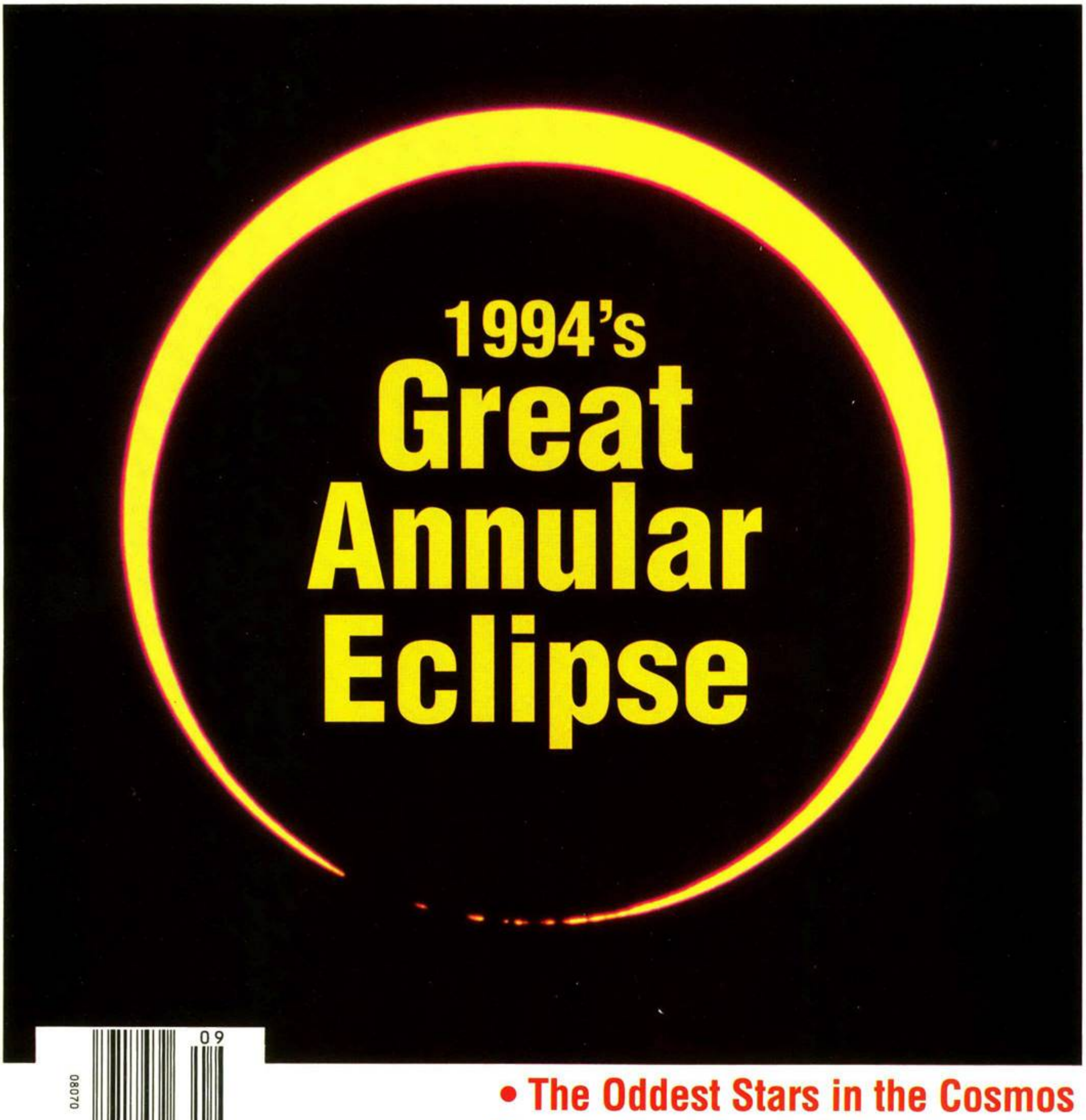

1994's Great Annular Eclipse

- The Oddest Stars in the Cosmos
- How to Beat the Guiding Gremlins

MEADE
MEADE LX200 EMC
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12" LX200

10" LX200
(shown with
optional
Superwedge)

8"
LX200

Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2295.**
10" LX200 Schmidt-Cassegrain	**$2895.**
12" LX200 Schmidt-Cassegrain	**$3995.**

Packing & shipping in 48 states: 8"—$105; 10"—$145; 12"—$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.
- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

If you're thinking of buying a computer-controlled Schmidt-Cassegrain, consider why Meade® LX200's are the largest-selling serious telescopes in the world:

1. More than *three times* the pointing accuracy—Other computer-controlled Schmidt-Cassegrains vaguely promise a ***"potential*** pointing accuracy of 0.09°." Meade LX200's in the altazimuth mode include precise corrections for atmospheric refraction and precession, and are **guaranteed to locate and place objects to within a pointing accuracy of 0.03°**, an accuracy that places objects **virtually dead-center in the field**. For CCD astronomy, with its inherent demands on telescope pointing accuracy, for locating and observing objects near the threshold of visibility, or simply to avoid constant re-centering of objects, a Meade LX200 is the essential tool of the advanced amateur.

2. Legendary Meade Super Multi-Coated (EMC) optics—The finest Schmidt-Cassegrain optics available, **multi-coated, as standard equipment, on all optical surfaces for maximum light transmission and image contrast.** *Competing SCT's do not offer multi-coatings even as an option.*

3. High-torque dual-axis drive systems—Powerful **18-volt** DC drives that operate **from any 115v.AC outlet**, using the small, standard-equipment AC Adapter **or from any 12v. automobile cigarette lighter plug**, using the exclusive Meade 12v./18v. Electronic DC Adapter (an optional accessory that weighs only 4 ounces). ***LX200 drives produce high torques impossible to achieve and sustain with competing penlight-battery powered telescopes.*** The LX200 easily handles additional payloads of a CCD imager, piggybacked guide telescope, or other auxiliary equipment; even with such additional weight, the telescope moves effortlessly across the sky, either automatically or by observer pushbutton control, at speeds from the sidereal rate to 8°/sec.

4. Heavy-duty fork mounts—By a wide margin the largest, most rigid in the industry, complemented by giant 4"-diameter polar ball bearings and by DC-servo-motor-driven worm gears on both telescope axes.

5. *Nine-speed* drives on both axes—Including photo-guiding (at **2x** sidereal rate); image centering and microslewing in the main telescope (at **32x** sidereal rate); image centering in the viewfinder (at **2°/sec.**); or fast-slew of the main telescope at any rate between **3°/sec** and **8°/sec.**, in **1°/sec.** increments.

6. *Thirty-six* built-in tracking rates—From quartz-controlled sidereal-rate tracking to incrementally variable solar, lunar, and planetary rates.

7. Permanently programmable Smart Drive™—Reduces periodic drive errors to 5 arc secs. or less, an observatory standard. Program ***once*** and store in memory indefinitely, even when the telescope is turned OFF.

8. Upgradable object-database library—Object databases on competing computer-controlled SCT's are *non-upgradable and fixed in size.* The LX200 allows for much larger object-databases. **And, for a limited period, you can obtain the Meade 64,350-object database FREE of charge!** *(See box at right.)*

Meade
ENTER
MODE
GO TO
N
W
S
E
ALT
SLEW 7
RET 8
M 9
FIND 4
FOCUS 5
STAR 6
CNTR 1
MAP 2
CNGC 3
GUIDE 0
PREV
NEXT

The modern design of the LX200 hand controller permits more than a dozen user functions, from automatic actuation and centering of any object in the 64,350-object database to brightness control of an illuminated reticle eyepiece.

9. Advanced Hand Control Design and Software—Competing telescopes do not even include a numerical keypad! To enter an object from the database, for example, you must scroll through each digit, ***typically using 20 to 30 keystrokes***. By comparison, the random-access software controlling the LX200's numerical keypad requires a **maximum** of 5 to 7 keystrokes. LX200 user-definable "sky tours" by object-type, brightness, and position may include every deep-space object in the 64,350-object database, if desired, or any user-defined subset thereof.

10. Ultra-reliable electronic systems—*Thousands* of Meade LX200's have been sold worldwide. State-of-the-art designs and production systems, combined with exhaustive laboratory and field testing, make these **the most trouble-free serious telescopes ever manufactured.**

11. Meade Version 3.20 software—The very latest in telescope operating systems. Permits quick ***(less than 10 seconds!)*** 2-star alignment of the LX200 in altazimuth mode, without requiring latitude or longitude input, without even leveling the tripod. Just use 2 easy-to-find reference stars and the telescope tracks and actuates GO TO with extreme precision.

FREE!

Through August 31, 1994, receive the Meade 64,350-object library at *no charge* when you order any 8", 10", or 12" LX200!

Buy a Meade 8", 10", or 12" LX200 Schmidt-Cassegrain before August 31, and we'll include the Meade 64,350-object database at no additional charge! Imagine having 64,350 celestial objects at the tip of your finger: *64,350 objects that you can actuate and center in the telescopic field just by entering and pressing GO TO on the hand controller.* **More than 6 times the size of object libraries included with competing telescopes**, the Meade 64,350-object library includes an incredible array of phenomena—virtually a lifetime of deep-space study, even for the advanced observer:

12,921	galaxies from the Uppsala General Catalog; the complete UGC catalog.
7,840	objects from the New General Catalog; the complete NGC catalog.
5,386	IC (Index Catalog) objects; the complete listing of IC objects.
21,815	variable stars; the complete listing from the General Catalog of Variable Stars.
15,928	stars from the Smithsonian Astrophysical Observatory (SAO) catalog of stars brighter than 7th magnitude.
351	alignment stars for the LX200 telescope.
110	Messier objects; the complete listing.
8	major planets from Mercury to Pluto.
64,359	**objects, total**

This special offer applies to telescopes ordered from your authorized Meade Advanced Products dealer between May 20 and August 31, 1994.

SPECIFICATIONS: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 SC optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; keypad handheld controller with digital readout display, permanently programmable Smart Drive™, 9-speed drive controls on both axes (7-speed on 12"), and GO TO controller; 64,350-object onboard celestial software library**; 25 ft. power cord and adapter for telescope operation from 115v.AC (DC capability for operation from auto cigarette lighter plug available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.
**Included during period of special offer, only.

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
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September 1994 Vol. 22, No. 9

ASTRONOMY®

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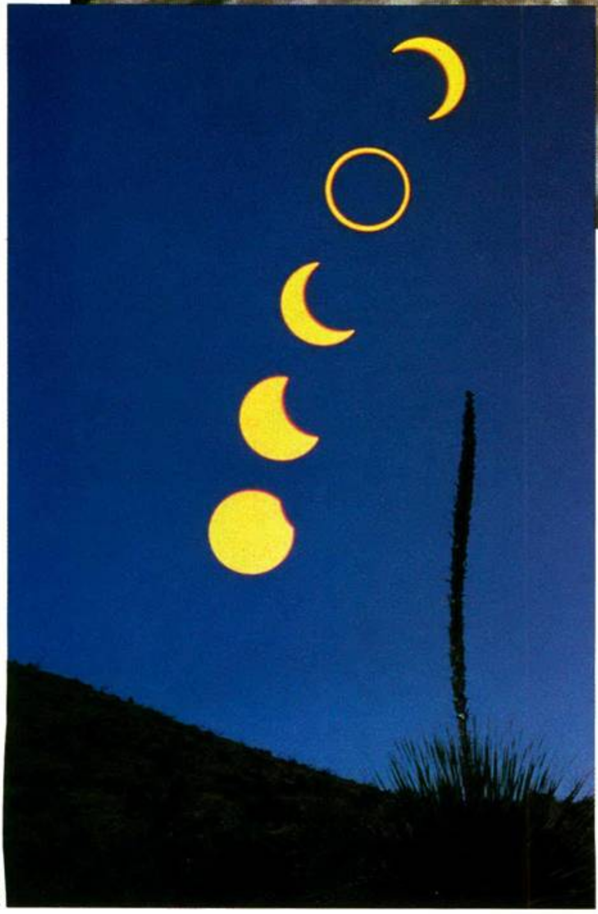
Clementine Science Team/USGS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COVER

SUNLIGHT SHINING through valleys near the Moon's north pole during May's annular eclipse created tiny spots of light called Baily's beads. This photo was taken on the northern limit of annularity near Deming, New Mexico, where beads were visible for more than four minutes. Photograph by amateur Alberto Levy.

BEHIND THE SCENES

Sharing the Fire

Wow! The annular solar eclipse on May 10 produced one of the most impressive floods of reader photos we've seen. And that goes double when you consider that annular eclipses are often thought of as poor "also-rans" when compared to total eclipses.

The beautiful weather certainly helped. If the entire eclipse track wasn't cloud free, it was nearly so. From northern Mexico and southeastern Arizona all the way across North America to the Atlantic, most eclipse watchers got a great view of a wonderful event (see page 72).

Many of the ASTRONOMY staff also took to the field. Dave Bruning went to a local school and showed the eclipse to 100 fascinated kids and teachers. Dave Eicher, Rich Talcott, and John Shibley all piled into a car and headed for Springfield, Illinois. There, at Abraham Lincoln's tomb (Dave chose the site — he's a Civil War buff, couldn't you guess?), the three set up their equipment and got a fine sequence of photos showing the progress of the eclipse.

Andy Manning, of Kalmbach's creative services department, set up a telescope here at the office for company staff, while Kim Bennett of ASTRONOMY's advertising department was at the Texas Star Party. She observed the partial phases of the eclipse from the Prude Ranch (which lay outside the path of annularity). Me? I was at Pt. Pelee National Park in Ontario, trying to bag a "two-fer" of my own. A peninsula on the north shore of Lake Erie, Pt. Pelee stood right on the eclipse's center line. Pelee is a big-league hot spot for birders during the second week of May (the peak time for migration), and the eclipse just added to the excitement.

No matter where you see it from, everyone experiences much the same thing. You watch closely, trying to spot that all-but-unobservable initial instant: first contact. Then over the next hour you check in on the Moon's progress across the Sun. Slowly, the sunlight shifts in quality, becoming dimmer and weirder. Shadow edges sharpen and turn strange. Colors intensify and seem to grow bluer. A breeze may pick up, and the air feels cooler. (At Pelee, the light dimmed so much that the sunlit black roof of the car felt distinctly cool to the touch.) Mid-eclipse finally arrives and if you're in the path, you'll see a dazzling ring around the Moon — or if you're near the edges of the path, lunar peaks and valleys break the Sun's limb into Baily's beads.

Whether you viewed it on your own or as part of a group, the eclipse was really a shared experience because all across the continent, thousands or even millions of people were doing as you were doing. Events like these are some of the great rewards of amateur astronomy — and they show how wide its appeal truly is.

Sincerely,

Robert Burnham
Editor

LETTERS

Fear Not from CCDs

In response to Mark Hladik's letter (May 1994), it seems a shame that he would allow the growth of high-tech, high-priced accessories like CCDs to reduce his simple enjoyment of astronomy. If he would visit someone with these new devices I'm sure he would appreciate the wonders these CCD cameras can perform. It is very challenging to get good results, but very exciting nonetheless.

Due to the great cost, I will never own a CCD system. In fact I am looking forward to having my first real telescope, an $8^{3}/_{4}$-inch reflector, set up in the next month or so. But it won't stop me from visiting my friends who own CCDs. Good luck to them. Have no fear, Mark, there will always be backyard astronomers enjoying their average telescopes. — *Maggie Daly, Ruislip, Middlesex, England*

Near the end of a recent CCD workshop in Berkeley, California, a fellow attendee asked if he might play devil's advocate long enough to wonder if all this new technology might scare away newcomers from amateur astronomy. I was amused to see Mr. Hladik's letter feeding into that same fear.

Here's what I conclude: If you're interested in astronomy and enjoy looking at the sky, what do you care if someone else has a telescope five times as large or a megapixel CCD on their telescope's rear end? Do you have an urge to quit driving when you see someone in a Ferarri? Would you give up kayaking if passed by a yacht? You either love what you're doing or you don't. — *Marc A. Weeks, Fairfield, California*

I can't believe anyone would leave the hobby because some equipment is expensive. I recently began studying astronomy. I had no idea how wonder-

(continued on page 14)

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Tracy Staedter Editorial Assistant
Julie Sherwin Editorial Secretary

Thomas L. Hunt Art Director
Gary Kachar Graphic Designer

U.S. and International Newsstand Distribution
I.C.D., The Hearst Corp., New York, NY 10019

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Tracy Lando Advertising Services Representative
Advertising Department (800) 558-1544
Joel Park The Environmental Magazine Network, (908) 671-4036

Canadian Newsstand Distribution
Telemedia Dist., Toronto, Ontario M4S 3B3

ASTRONOMY is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Editorial phone: (414) 796-8776; advertising: (800) 558-1544; customer service: (800) 446-5489; subscriptions: (800) 533-6644 7 days a week, 24 hours a day; fax (414) 796-0126. Copyright © 1994 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second-class postage paid at Waukesha, WI, and additional mailing offices. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription price: 1 year $27. Canadian and foreign: 1 year $38, GST (#R122713209) included; please remit in U.S. funds. Not responsible for unsolicited materials. *POSTMASTER: Send address changes to* Astronomy, 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187. Canadian second-class postal permit no. 545775. Printed in the U.S.A.

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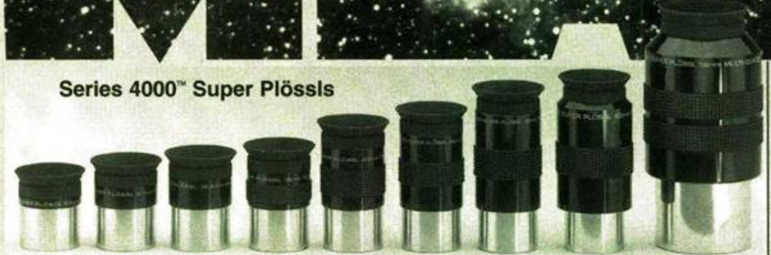
Series 4000™ Super Plössls



Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types for 1994, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.29)
32mm (52°); **40mm** (44°) each: **109.95** (3.79)
56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5° at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

Series 4000™ Super Wide Angle

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Series 4000™ #140 2x Apochromatic Barlow Lens

The most advanced Barlow Lens available for commercial telescopes; includes 3-element, air-spaced optics, multi-coated. Unmatched in image resolution, contrast and color correction. Accepts 1.25" eyepieces. Lens dia. 28mm; clear aperture 26mm.

$79.95 (3.29)

SALE! Meade® Schmidt-Cassegrain Accessories

Through September 30, 1994, buy Meade premium-quality Schmidt-Cassegrain accessories at special sale prices and save up to 16%!

Series 4000 f/6.3 Focal Reducer/Field Flattener: Regular $129.95; Sale Price $114.95. Save 11%.

Series 4000 Nebular Filters: #911B — Regular $99.95; Sale Price $89.95. Save 10%. #911N — Regular $119.95; Sale Price $99.95. Save 16%.

T-Adapter for SCT: Regular $26.95; Sale Price $22.95. Save 15%.

Basic Tele-Extender for SCT: Regular $29.95; Sale Price $26.95. Save 10%.

Variable Tele-Extender for SCT: Regular $39.95; Sale Price $35.95. Save 10%.

#929 2" Diagonal Mirror for SCT: Regular $99.95; Sale Price $89.95. Save 10%.

Series 4000 Super Plössl 56mm Eyepiece (2"): Buy one eyepiece at the regular price of $229.95 and receive the #929 2" Diagonal Mirror FREE.

Series 3000 Plössl 40mm Eyepiece (1.25"): Regular $79.95; Sale Price $69.95. Save 12%.

All prices plus shipping, as noted in product descriptions. This offer is valid between June 20 and September 30, 1994, at participating Meade dealers and is subject to product availability.

Series 3000™ Plössls

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$57.95** (3.45) **Any 2: $52.95** each; **Any 3: $48.95** each; **Any 4 or 5: $46.95** each.

Series 3000™ Plössl 40mm

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Series 4000 Photo-Visual Color Filters (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

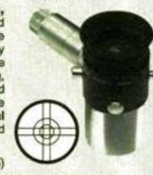
each	**$14.95**	(2.29)
Moon Filter #ND96–Reduces brightness by 87%.	**16.95**	(2.29)
Set #1–4 filters: #12, #23A, #58, #80A	**54.95**	(2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**54.95**	(2.98)
Set #3–4 filters: #8, #21, #38A, #56	**54.95**	(2.98)
Sets #1 & #2–8 filters	**99.95**	(3.45)
Sets #1, #2, & #3–12 filters	**144.95**	(3.79)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95**	(2.98)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95**	(3.29)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95**	(3.29)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95**	(2.98)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95**	(3.29)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95**	(3.29)

World's Most Advanced Illuminated Reticle Eyepiece



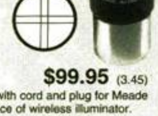
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

MA 12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

MA 12mm—Same as above but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **$99.95** (3.79)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

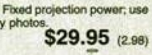
.965": $27.95 (2.98) **1.25": $29.95** (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

Tele-Extenders



For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to any eyepiece-holder. Use with T-mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos.

$29.95 (2.98)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece.

$39.95 (2.98)

T-Adapters for SCT's

For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25"

$59.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, these 3-element Modified Achromatic eyepieces give sharp, faithful, well-corrected images of the moon, planets, and deep-space at an economical price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders: 800-843-4780; Info.: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

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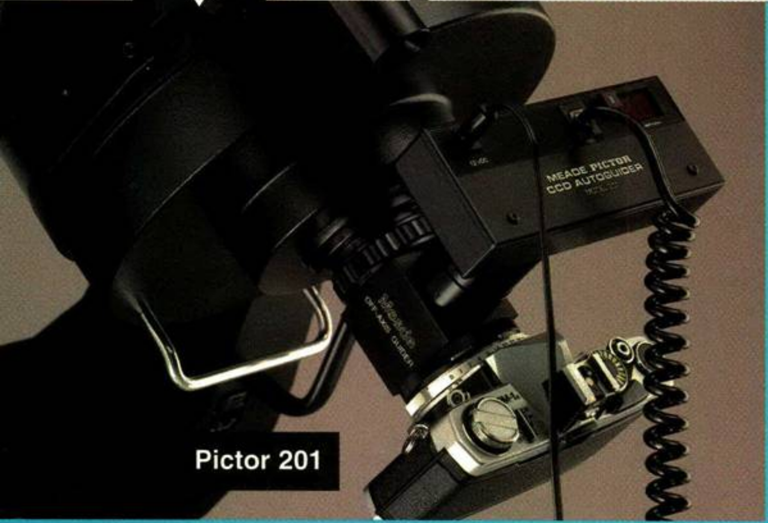
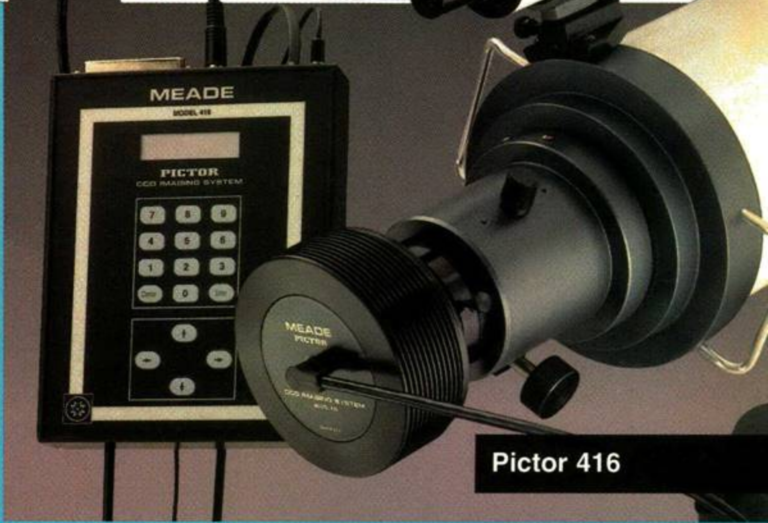

MEADE PICTOR
CCD AUTOGUIDER
OFF-AXIS GUIDER

Pictor 201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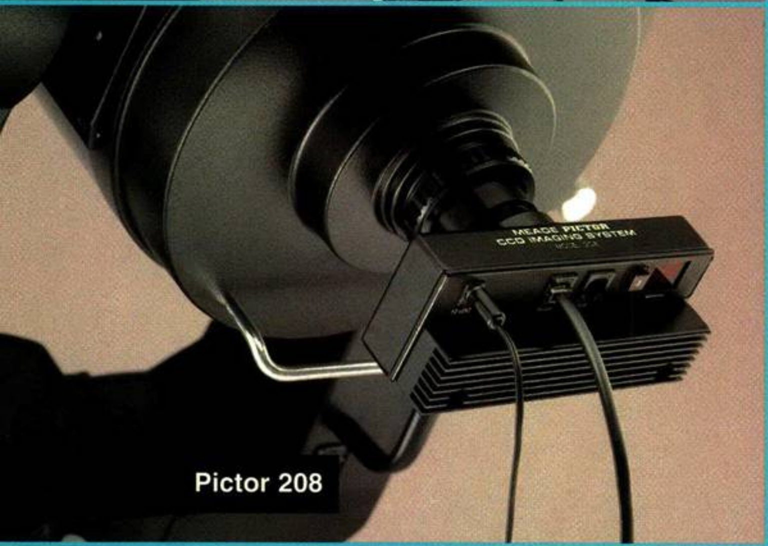
Pictor 416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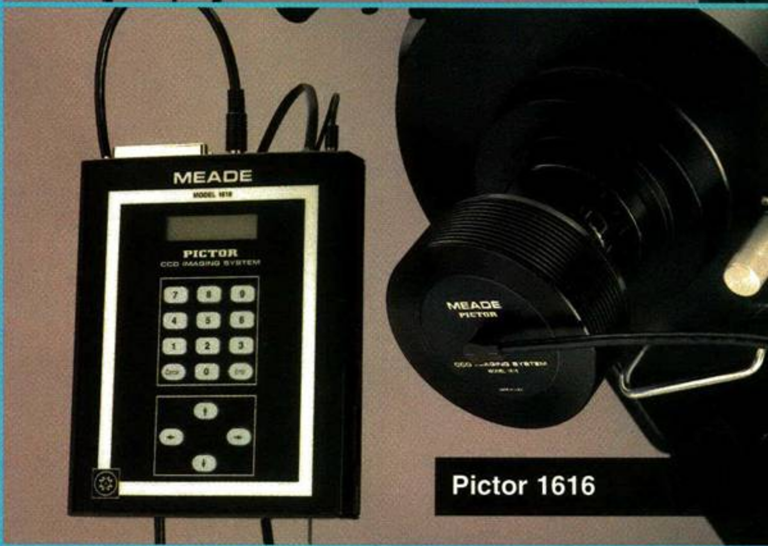
Pictor 208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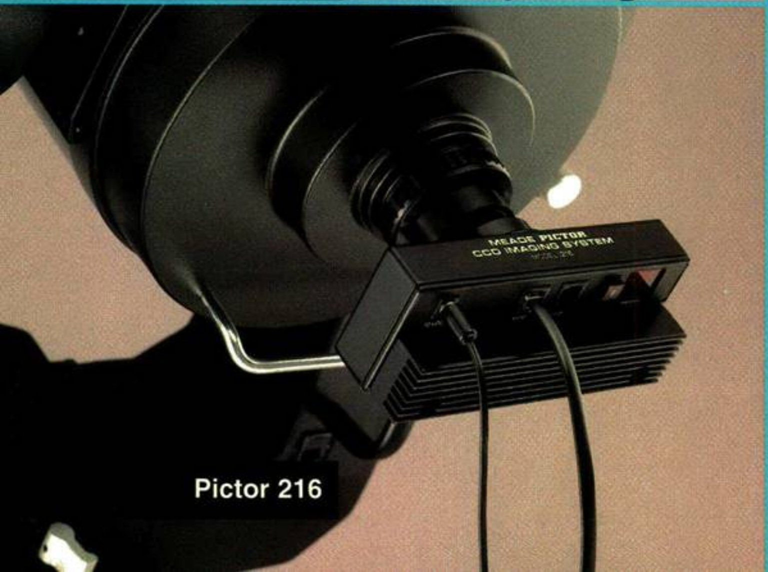
Pictor 1616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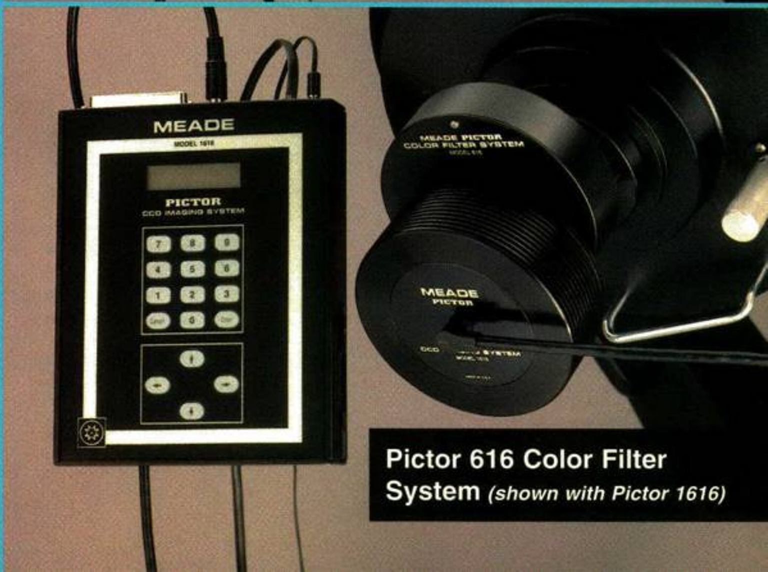
Pictor 216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Pictor 616 Color Filter System *(shown with Pictor 1616)*

Pictor™ Series CCD IMAGERS

For the beginner, or for the most advanced observer, the *real* CCD revolution is here!

Imagine—*with your telescope*—capturing an image of Jupiter that appears to have been taken with a 36" observatory instrument!

Or obtaining, in 2 minutes or less, *without guiding*, an image of the spiral galaxy M51 that outresolves 30-minute photographic exposures. Or imaging a supernova in an obscure *18th-magnitude* galaxy. Meade CCD imagers make all of this possible, and more.

Meade Pictor Series CCD Imagers bring the CCD revolution even to the beginner: all models, including the least-expensive unit, are simple to use, without a multitude of complex adjustments and settings. **And yet, because of state-of-the-art Meade electronic and software design, this simplicity is accomplished simultaneously with the most advanced CCD image resolution and performance in the history of amateur astronomy.**

From the Pictor 201 Autoguider at $395, to the Pictor 1616 Professional CCD Imaging System at $6995, and with three models in between, there's a Meade CCD system to fit your budget and your imaging requirements. Each model is the finest obtainable, by far, in its price class.

Pictor 201 Autoguider: The first ultraprecise, moderately-priced CCD autoguider, the Pictor 201 yields flawless, fully automatic photographic guiding on any telescope equipped with a dual-axis drive corrector; optional connectors enable easy interfacing between your drive corrector and the 201 Autoguider. On Meade LX200 and CDS-driven APO models, or on other telescopes equipped with a CCD/autoguider jack, the self-contained 201 plugs directly into the telescope's power panel; no host PC or separate control box is required. Used with an off-axis guider and 35mm camera body, the Pictor 201 locks on to a guide star and automatically makes all required dual-axis corrections for perfectly guided astrophotographs. Use it *once*, and you'll never manually guide again! **$395*** + $10 packing and shipping in the 48 states.

Pictor 208 CCD Autoguider/Imager: Incorporating the Texas Instruments TC-255 CCD microchip, the Pictor 208's 3.3mm x 2.4mm active area is the largest available in any CCD unit under $1500. Ideal for the beginning CCD user, the thermoelectrically cooled 208 includes an 8-bit A/D register permitting 256 shades of image brightness. The Pictor 208 requires no external control box: all microelectronics and control buttons are housed on or within the small 5.5" x 2" x 1.7" main unit. Operation is through any Windows™ or Mac™-based PC. Simple to use, quick to set up, *the Pictor 208 is perfect for the demanding first-time CCD user on a more limited budget.* When used with a Meade LX200 and electric focuser, the 208 permits auto-focusing and auto-mosaic features. Autoguiding circuitry, software, and capabilities are identical to the Model 201, above. **$795** + $15 P & S.

Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the Model 208, and designed around the same Texas Instruments TC-255 CCD chip, the Pictor 216 includes a major advantage: a 16-bit A/D converter permitting 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs. **$1195** + $15 P & S.

Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. The 416 includes more than *four times* the pixel quantity, more than *twice* the pixel density, and about *one-tenth* the dark current of competing units. And, with its standard-equipment SCSI interface, *the 416 can full-frame download to its host computer in one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome: the auto-mosaic feature, for example, permits imaging of an arbitrarily large sky area, creating an image-montage of adjacent sky regions *automatically* on user command. **$2495** + $25 P & S.

Pictor 1616 CCD Autoguider/Imager: For professional-level applications, the Meade Pictor 1616 utilizes the Kodak KAF-1600 CCD microchip, one of the largest (13.80 x 9.20mm) such chips currently in commercial production. Identical in pixel density and dark current to the Pictor 416, but with 4 times the chip area, the 1616 permits imaging of very large sky areas and is the finest CCD imaging system available at under-$10,000. **$6995** + $40 P & S.

#616 Color Filter System: Complementing Pictor Models 216, 416, and 1616, the Model 616 Color Filter System enables superb tri-color imaging, *fully-automatically,* without the tedious trial-and-error approach of competing units. Choose the object-type or planet to be imaged, and the Pictor's software does the rest, rotating each color filter into position and correctly timing each exposure for the optimal tri-color result. Alternately, color imaging may be performed in the manual-mode, according to user command. Special Poisson-curve interference filters, unique to the Meade filter system, achieve levels of color fidelity heretofore unavailable. **$695** + $10 P & S.

SPECIFICATIONS: MEADE PICTOR SERIES AUTOGUIDER/IMAGERS

	Pictor 201	Pictor 208	Pictor 216	Pictor 416	Pictor 1616
CCD Chip	Tex. Instr. TC-255	TC-255	TC-255	Kodak KAF-0400	Kodak KAF-1600
Dimensions	3.30 x 2.40mm	3.30 x 2.40mm	3.30 x 2.40mm	6.90 x 4.60mm	13.80 x 9.20mm
Pixels	336 x 242	336 x 242	336 x 242	768 x 512	1536 x 1024
Pixel Size	10.0 µm square	10.0 µm square	10.0 µm square	9.0 µm square	9.0 µm square
In 8" f/10 telescope:					
Pixel Size	1.0 arc secs	1.0 arc secs.	1.0 arc secs.	0.9 arc secs.	0.9 arc secs.
Field of View	5.6' x 4.1'	5.6' x 4.1'	5.6' x 4.1'	11.7' x 7.8'	23.3' x 15.6'
Full Well Capacity (e-)	70,000	70,000	70,000	85,000	85,000
Dark Current	87e-/5 secs. @20°C	< 8e-/5 secs. @ -5°C	< 8e-/5 secs. @ -5°C	< 1e-/5 secs. @ -20°C	< 1e-/5 secs. @ -20°C
A/D Conversion	8 bit	8 bit	16 bit	16 bit	16 bit
Brightness Levels	—	256	65,536	65,536	65,536
Thermoelectric Cooling	none	-25°C	-25°C	-40°C, 2-stage	- 40°C , 2-stage
Shutter	—	electronic	electronic	electro-mechanical	electro-mechanical
SCSI Interface	—	no	no	yes	yes
With LX200 Telescope:					
Auto-focus Capability	—	yes	yes	yes	yes
Auto-mosaic Capability	—	yes	yes	yes	yes
Accepts #616 Color Filter System	—	no	yes	yes	yes
Dimensions: Head	5.5" x 2" x 1"	5.5" x 2" x 1.7"	5.5" x 2" x 1.7"	5" dia. x 2.2"	5" dia. x 2.2"
Controller	—	—	—	9" x 7" x 1.2"	9" x 7" x 1.2"
Price (plus packing & shipping)	$395	$795	$1195	$2495	$6995

- *All prices shown are suggested U.S.A. mail-order prices, not including any applicable sales taxes.
- The all-new 76-page **Meade 1994-95 General Catalog** ($3.00) is available directly from Meade Instruments or from any authorized Meade dealer.
- For further details call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.
CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders: 800-843-4780; Info.: 818-505-8424.
CITY CAMERA, Dearborn, MI.
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LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.
SHUTAN CAMERA & VIDEO, Chicago, IL.
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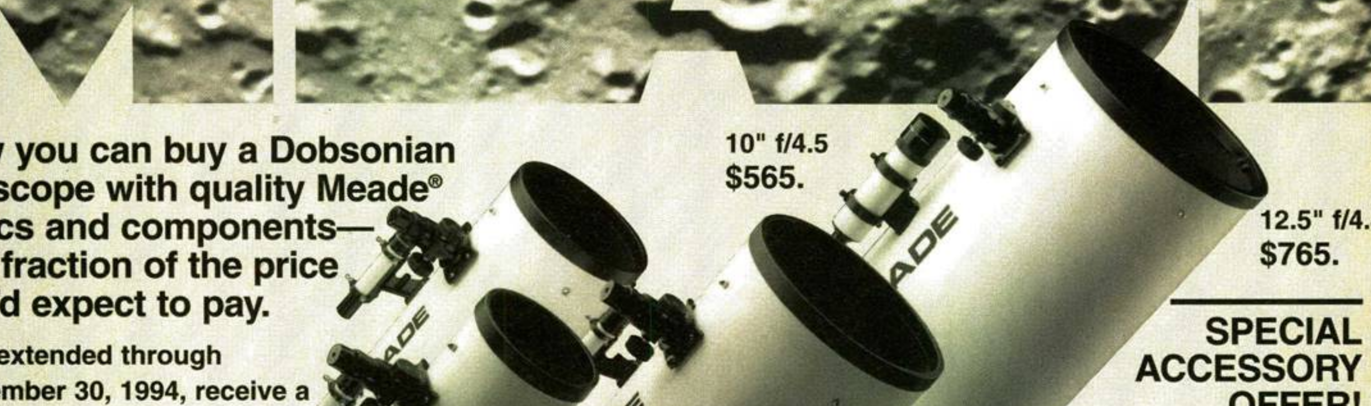
Now you can buy a Dobsonian telescope with quality Meade® optics and components—at a fraction of the price you'd expect to pay.

And, extended through September 30, 1994, receive a $125 Accessory Package for only $29.95!



10" f/4.5
$565.

12.5" f/4.8
$765.

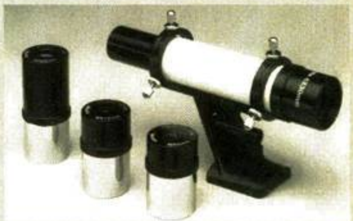
8" f/6
$395.

Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

6" f/8
$295.

SPECIAL ACCESSORY OFFER!

Through September 30, 1994, at the time you order any Starfinder 6", 8" 10", 12.5", or 16" Dobsonian Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces *and* the Meade #637 6 x 30mm coated achromatic viewfinder for a *total* of only $29.95! Purchased separately, the 2 additional eyepieces and viewfinder sell for $125.85!** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces, with #637 6 x 30mm viewfinder.)*



Starfinder Dobsonian 16

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16" f/4.5
$1195.

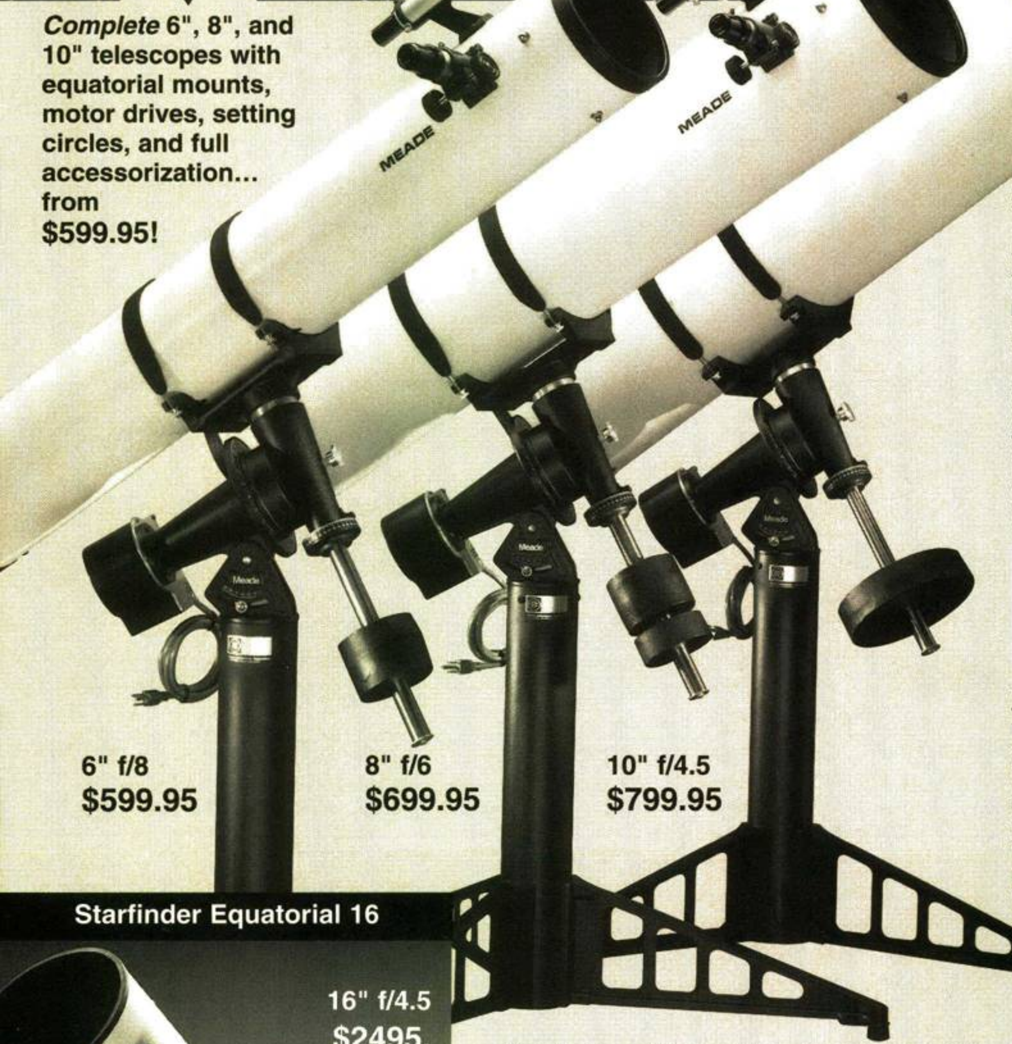
See the Meade General Catalog for details.

Includes giant #682 focuser; shown with optional 8 x 50mm viewfinder.

Compare Meade Starfinders *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® glass!** Unlike the plate-glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians include the *exact same* professional-quality Grade-A, fine-annealed Pyrex® optical systems used on Meade Starfinder Equatorial Reflectors. Optics that meet the theoretical limits of resolution for their apertures.
- **Precision Rack-and-Pinion Focuser!** An industry-standard full-size rack-and-pinion system with 2.6" of focus travel.
- **Fully-Adjustable 4-vane Secondary Mirror Systems!** *Rigid 4-vane systems* that permit precision alignment of the secondary mirror to the primary mirror.
- **Rigid, Durable, Beautiful Dobsonian Mountings!** Mountings that provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects anywhere in the sky. Each mount is manufactured of cabinet-quality materials and designed for a lifetime of use. Handles are provided for easy portability.
- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(facing page)*. All telescopes include a multi-coated MA25mm eyepiece as standard equipment. Each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.
- **Performance!** A Meade Starfinder Dobsonian or Equatorial Telescope opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects–nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space astrophotography.
- **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. *16"–$45 packing*, shipped truck freight collect.
- **To Order:** Contact one of the authorized mail-order dealers on the facing page.

STARFINDER™ EQUATORIALS



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10" f/4.5
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■ **Electric Motor Drive** (115v/60Hz) with 6 ft power cord: permits **fully automatic** tracking of celestial objects; plugs into any standard outlet.

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■ **Optional Accessories:** See the Meade accessories ad in this issue. Additional systems, including #55 Manual Declination Control, #43 Drive Corrector, and #47M Dual-Axis Drive Corrector, are described in the Meade General Catalog.

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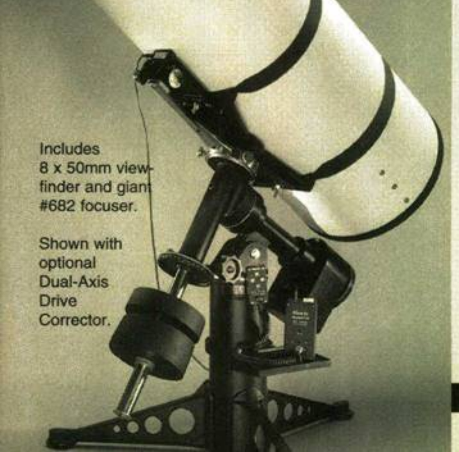
■ **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"–$65; 8"–$75; 10"–$90. 16"–$55 packing, shipped truck freight collect.

■ All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.

■ **All-new 1994-95 Meade General Catalog**–$3.00 postpaid–is available from any authorized Meade dealer or directly from Meade Instruments.

■ For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

Starfinder Equatorial 16



16" f/4.5
$2495.

See the Meade General Catalog for details.

Includes 8 x 50mm viewfinder and giant #682 focuser.

Shown with optional Dual-Axis Drive Corrector.

Standard equipment on 6", 8", and 10" models includes:

■ **Superb Optical System:** Includes hand-figured parabolic primary mirror that meets the theoretical limit of resolution for its aperture, with matching elliptical flat secondary mirror. Both mirrors multi-coated and made of low-expansion, Grade A, fine-annealed Pyrex® glass.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs, for rock-solid support of the optical tube. The telescope moves effortlessly from object-to-object on precision bearing surfaces. Polar and declination shafts are 1" solid steel. Setting circles on both axes facilitate the location of faint objects directly from their catalogued coordinates.

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ful it is! I nearly had tears come to my eyes when I paged through your "Reader Reports" section. I've always dreamed of seeing other planets and galaxies.

I'm now saving up for a telescope and hope that one day I'll be one of those guys sending in pictures. How foolish it would be to worry about having sophisticated electronics and to forget the pure, simple beauty of the night sky. — *Jeremiah Seifert, St. Thomas, U.S. Virgin Islands*

Whereas Mr. Hladik has been an amateur astronomer for over 30 years, I have been hoping to become one for more than 50 years. I never made it until last year when I spotted a 6-inch reflector in a pawn shop at a "giveaway" price. It needed a great deal of tender loving care and some elbow grease, but now I have my own telescope.

Recently I've had my first views of the Andromeda Galaxy and the Orion Nebula through my own telescope. I know that there are plenty of people out there who enjoy simply looking at the sky's wonders without getting caught in a race to buy. I'm one of them. Come join us, Mark — the views are terrific! — *John Hennessy, Sr., Odessa, Texas*

I agree with Mr. Hladik 100 percent. After many years of being out of astronomy as a hobby I was recently asked to teach it at a local high school. I couldn't believe how the hobby had changed.

Gone are the relatively cheap telescope kits. They may not have produced great telescopes, but they drew in many interested young people who entered the hobby and moved up to more substantial equipment. Now the cheapest small reflector on a flimsy equatorial mount sells for $500, beyond the economic range of youthful experimentation.

How can a young beginner even think about getting into this hobby? — *William Harvey, Natalia, Texas*

I hope that Mr. Hladik and others like him will come to realize that hobbies aren't about spending money or feeling intimidated by those who own more toys. Hobbies are about enjoying yourself, and to heck with other people's squabbling.

Sure, plenty of ads encourage me to refinance the house and buy computerized scopes, CCDs, and multithousand-dollar scopes that do everything but wash the laundry. But I don't need any of those things to enjoy astronomy — to watch a meteor shower, gaze at the Moon, or gasp at the beauty of a distant galaxy.

I know ASTRONOMY must accept advertising and that advertisers create a climate so we think we "need" much of the gadgetry manufacturers have devised over the past several years. But I hope readers don't forget what astronomy is all about — the sheer enjoyment of the night sky. — *Charles Johnson, Petaluma, California*

California Dreamin'

The article by Norman Looper, "A Pilgrimage to Palomar" (January 1994) touched me because I experienced the same feelings. In the 1950s I was a schoolboy in Berlin and was very interested in astronomy. At that time my parents were too poor to buy a telescope or binoculars. We simply heard in our local astronomy club about the great discoveries being made at Palomar Mountain. I had no idea where Palomar was, just that it was in the great land of America.

Some decades later I was on vacation in California and decided to visit the dream of my youth. It was a trip I took alone — my family preferred to stay at the beach — but I enjoyed seeing the great dome immensely. Both joy and melancholy ran over me as I visited astronomy's hallowed ground. — *Rolf Ganger, Berlin, Germany*

Hubble Down Under

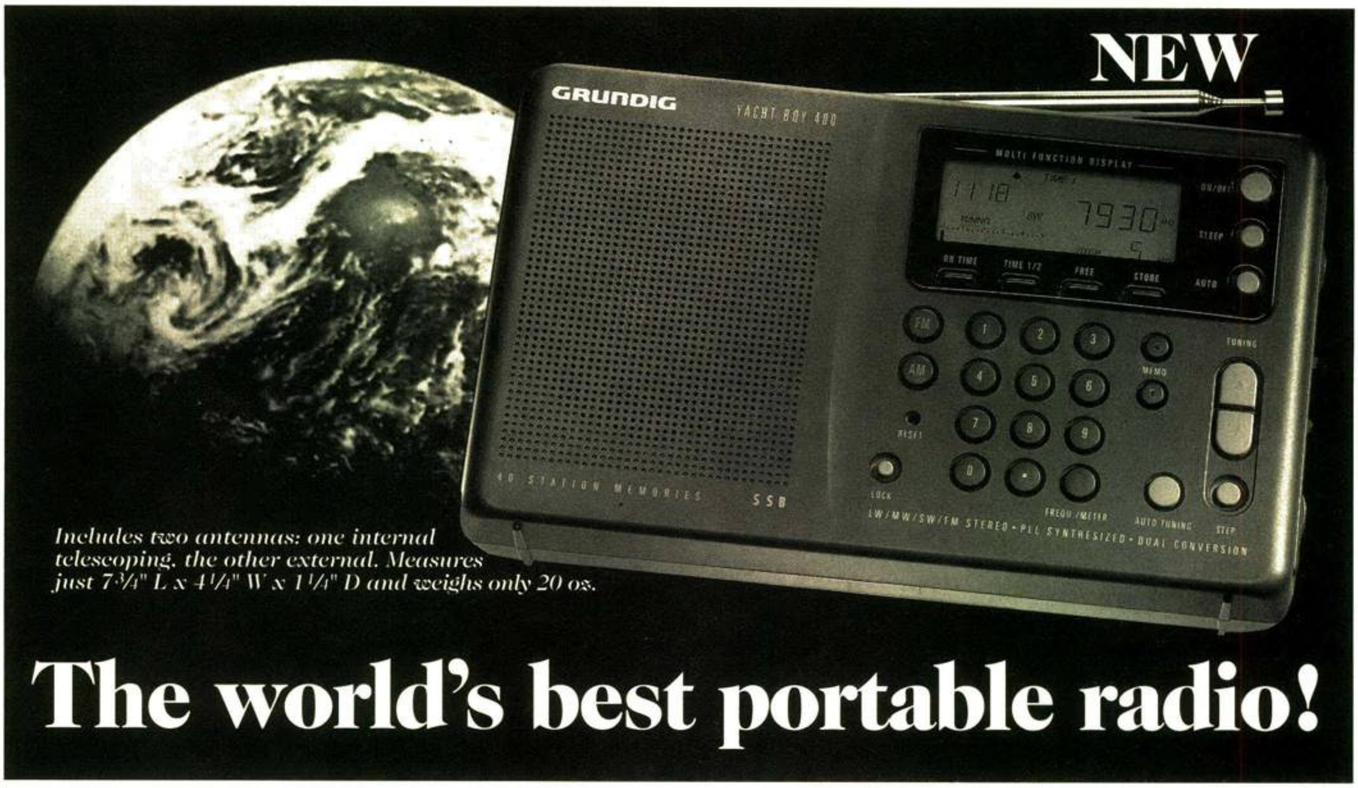
While enjoying the cover of your March 1994 issue, I noticed that the repaired Hubble Space Telescope was floating over South Australia, specifically between its border with Victoria and with West Australia. The telescope appears over the outback, and the photographer is looking southward.

A closer look shows that between the arm of the shuttle and the telescope lies the Yorke Peninsula, off which appears Kangaroo Island. The arm obstructs the Fleurieu Peninsula and the telescope the Eyre Peninsula. As you can see, we Southern Hemisphere ASTRONOMY readers have clear day skies as well as wonderful night skies. — *Mark Nelson, Carnegie, Australia*

Correction

The sketch of Jupiter by Viktor Zinoviev on page 113 of the May 1994 issue was made with a 40 cm (16-inch) refractor at 217x. ☐

ASTRONOMY welcomes suggestions and additional information about articles and astronomy in general. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on Internet, use 72000.2704@CompuServe.com. Letters may be edited for length and clarity.



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VIEWPOINTS

Dancing with Angels

by Ron Evans

With a bemused expression on his face, a curious straggler at the star party asked, "Why do you stargazers stay out all night just looking up at stars?" I had heard the question before — phrased with varying degrees of sarcasm — and the underlying implication was always the same: We amateur astronomers are an odd lot. But this questioner somehow seemed sincere, so I tried to answer.

I don't remember exactly what I said, but my answer seemed hollow. How could I explain what I did under diamond-dappled skies, far from the artificial aurora of city lights? How could I convey the mystical love I felt for the universe and my yearning to commune with it? My inquisitor listened to my answer (hollow or not), thanked me for letting him look through my scope, and walked away.

But his question remained. In the days following, I began jotting down some reasons for this love affair with the skies, hoping that he and others puzzled by nocturnal pokings around in the cosmos will read these words and come to understand at least some of us amateur astronomers.

First, time spent beneath the stars, ironically, makes us feel both vital and insignificant. The unimaginably remote and majestic worlds out there restore priorities — in all that vastness we seem to matter less. Oddly enough, this can be comforting: If we are insignificant, our worries and concerns are also insignificant. So cares vanish in the velvet night. This leads to a new vitality, for no longer fragmented by the demands of daily life, we revel under the healing of distant suns. On rare occasions when the magic eludes us, we can remember the phrase from Oscar Wilde's *Lady Windermere's Fan* and still believe ourselves fortunate: "We are all in the gutter, but some of us are looking at the stars."

Another reason is that the heavens feed us — first the body, then the soul, then the mind. I call out as a meteor lances the frosty night and watch my breath form a miniature gaseous nebula. I inhale the frigid air, am chilled by the too close sound of wolves, smell the sweet odor of burning oak in an unseen fireplace. This sensory richness changes my spirit: I begin to feel a part of something infinitely larger than flesh can fathom. This leads to thoughts I cannot speak, possibilities too grand for expression.

Also, in this venture is purity of purpose. We stalk but do not kill, collect but do not hoard. Stored in wrinkled cortex are images that delight; objects have not been snatched from the sky but remain for other generations. We take only sensory impressions from nature. We experience fellowship with kindred minds that share in the celestial ballet, with others who have danced with the angels in the pale moonlight.

Fourth, the skies provide mystery, magic, and majesty, not security. They teach us the vanity of seeking "final" answers and compel us to come up with better questions. We are blessed in that we can wonder.

Fifth, many pleasant evenings under the stars are enriched by the eloquence of ordinary people grappling with the extraordinary. Robert Frost relates this phenomenon beautifully in his poem, "The Star Splitter." Two men are observing double stars. The first, Bradford, had purchased his telescope with insurance money obtained by burning down his house. The second man speaks:

Often he bid me come and have a look
Up the brass barrel, velvet black inside,
At a star quaking at the other end.
I recollect a night of broken clouds
And underfoot snow melted down to ice,
And melting further in the wind to mud.
Bradford and I had out the telescope.
We spread our two legs as we spread its three,
Pointed our thoughts the way we pointed it,
And standing at our leisure till the day broke,
Said some of the best things we ever said.

So we dream of star-pronged summer nights as we huddle in the gathering chill of December's breath. We peer into limitless depths as if searching for the fountainhead of the pale river of light coursing above us. We drink deeply, parched spirits refreshed, and speak frail words that build windows so others may see our deepest and best selves.

Finally, we do it all for fun! Fun! Most of us would admit this without hesitation. *Observing the universe is fun.* We shed adult shackles that chafe the spirit. We are reminded of faraway times and games prolonged beyond the setting sun. Gazing into the beginning of everything, we are young again. The child within is set free. Remembering the joy of a time we thought would last forever, we play in the starry night. □

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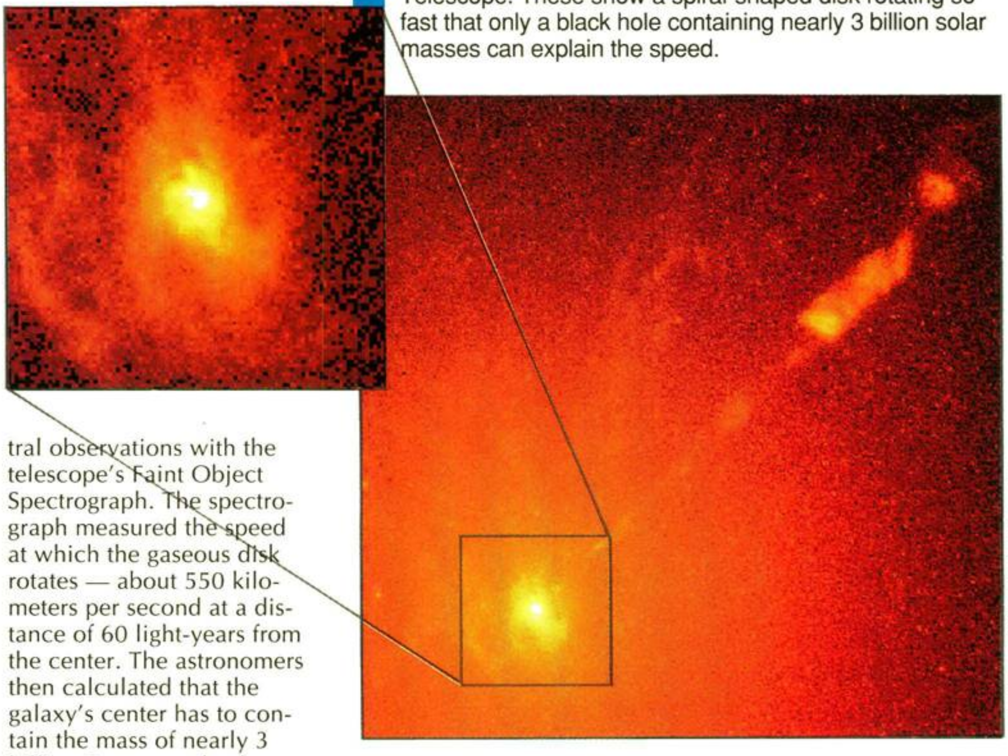
ASTRONEWS

A Black Hole in M87

Astronomers observing with the Hubble Space Telescope have found conclusive evidence for a massive black hole in the core of the giant elliptical galaxy M87. Although earlier studies hinted that a black hole lurked at the center of this galaxy, located 50 million light-years away in the Virgo cluster of galaxies, the most recent Hubble findings confirm it. "If it isn't a black hole, then I don't know what it is," says Holland Ford of the Space Telescope Science Institute and The Johns Hopkins University, the leader of the team that explored the galaxy's nucleus.

Hubble's Wide Field/Planetary Camera 2 found a spiral-shaped disk of hot gas at the center of the galaxy, something never before seen in an elliptical galaxy. But the proof of the black hole's existence came from spectral observations with the telescope's Faint Object Spectrograph. The spectrograph measured the speed at which the gaseous disk rotates — about 550 kilometers per second at a distance of 60 light-years from the center. The astronomers then calculated that the galaxy's center has to contain the mass of nearly 3 billion Suns to make the disk spin so rapidly. The region clearly possesses only a tiny fraction of the number of stars needed to make up that mass.

"Now it all knits together," says Ford. "We see a disklike structure that appears to have spiral structure, and it's rotating [extremely fast]." Over the next few months, the astronomers will try to peer even closer to the galaxy's center, where the disk should be spinning at even higher speeds, to improve the measurement of the black hole's mass.



A WHIRLPOOL OF GAS SWIRLS around a massive black hole at the center of the active galaxy M87. Although astronomers previously suspected a black hole powered M87's brilliant jet of high-speed electrons (seen running diagonally across the image), proof awaited detailed images and spectra from the repaired Hubble Space Telescope. These show a spiral-shaped disk rotating so fast that only a black hole containing nearly 3 billion solar masses can explain the speed.

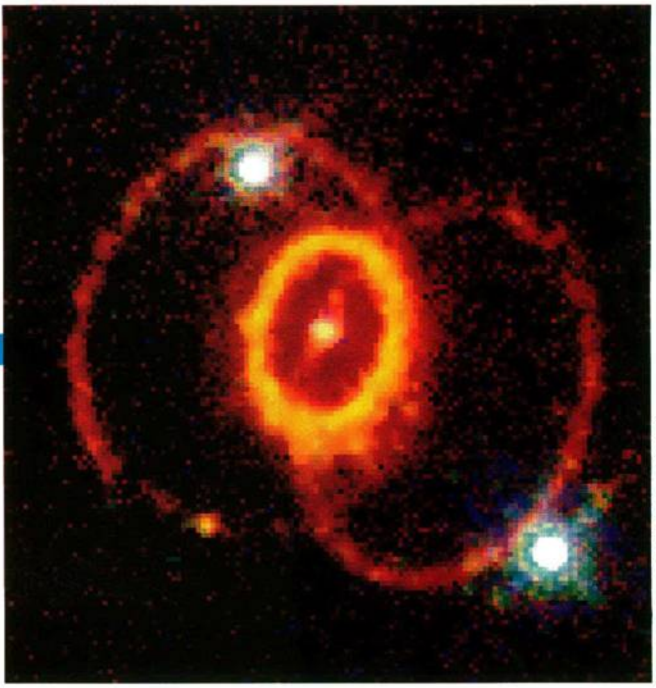
Holland Ford (STScI/JHU), NASA, et al.

Mysterious Rings Circle Supernova 1987A

New images from the Hubble Space Telescope show a trio of rings surrounding the site of Supernova 1987A. Although all three rings had been seen before from the ground (see AstroNews, July 1994), the highly detailed Hubble images reveal for the first time that the two outer rings may be mirror images of one another. The details in these rings "are completely unlike anything we had expected to see," said Chris Burrows of the European Space Agency and the Space Telescope Science Institute, leader of the team that took the Hubble images.

Burrows hypothesizes that the rings, each a few light-years in diameter, may be "painted" on a gaseous nebula by a high-energy beam of radiation or particles emanating from a previously unknown stellar remnant.

The remnant presumably was part of a binary system



A THREE-RING EXTRAVAGANZA surrounds Supernova 1987A, the remains of a 1987 stellar explosion in the Large Magellanic Cloud. This image from HST's Wide Field/Planetary Camera 2 shows a bright central ring as well as two fainter, outer rings that appear to be mirror images of each other.

Chris Burrows (ESA/STScI) and NASA

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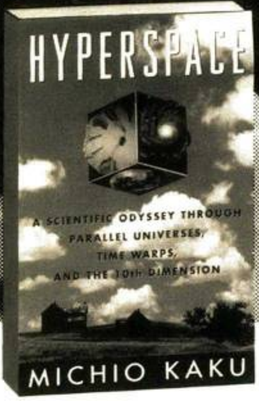
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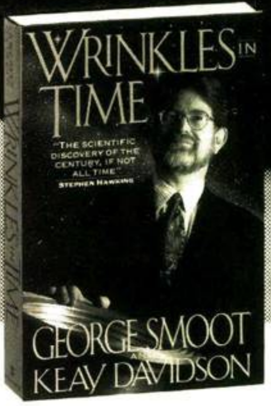
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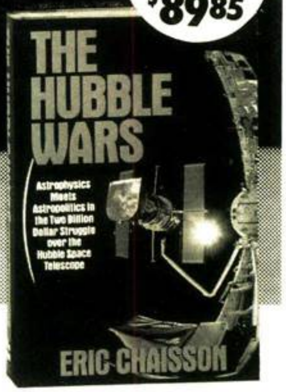
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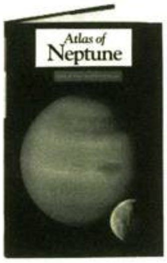
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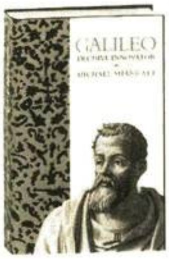
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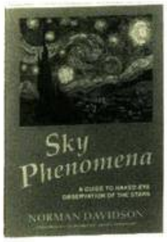
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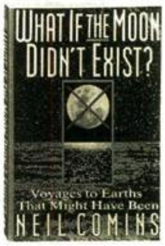
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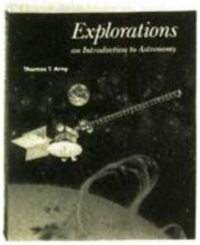
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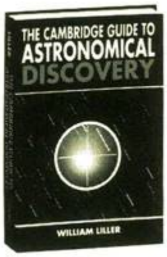
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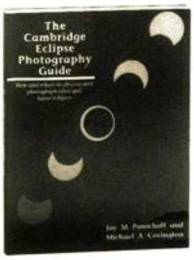
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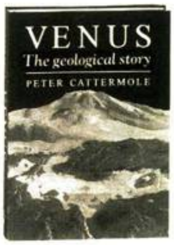
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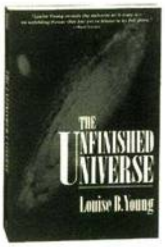
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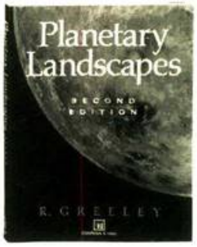
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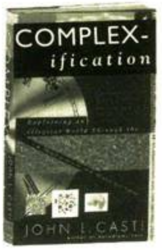
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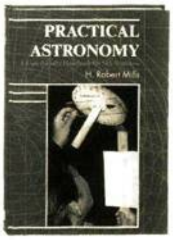
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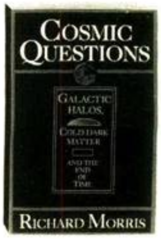
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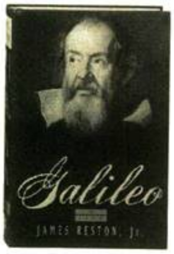
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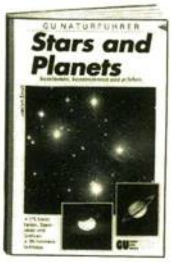
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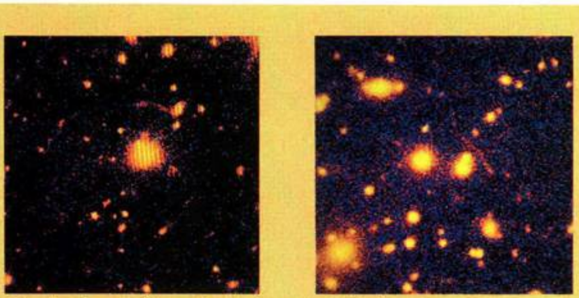
© Newbridge Communications, Inc. Astronomy 9/94 that orbited Sanduleak −69°202, the star that became the supernova in 1987 when it exploded in the Large Magellanic Cloud. One of the binary components would have to be a compact object, either a neutron star or black hole, and the other a normal star dumping material onto its companion. As the material falls onto the compact object, it gets heated and is then blasted back into space along two narrow jets. As the object spins, the twin jets sweep through space much like a lighthouse beam.

The jet model explains why the rings appear to be mirror images of each other and why they appear to be symmetric about a point offset about one-third of a light-year from the center of the explosion. A dim object appears at that location, presumably the stellar remnant generating the jets.

Based on previous HST images and ground-based photos of lower resolution, astronomers had expected to see an hourglass-shaped bubble. The hourglass shape would arise from stellar winds blown by the supernova's progenitor star. In an earlier red supergiant phase, the wind was relatively slow and denser in the equatorial plane of the star. The subsequent blue supergiant phase featured a faster wind that tended to break out at the poles of the star.

Energetic radiation from the supernova illuminated the dense gaseous material in the equatorial "waist" of the hourglass, explaining the bright central ring. Burrows suggests that the two outer rings are painted on the surface of the hourglass by the jets originating from the stellar remnant. Astronomers could confirm this model within the next year or so, when the remnant, if it exists, should collide with the supernova's expanding cloud of ejecta.



Massimo Ramella/Osservatorio Astronomico, Trieste

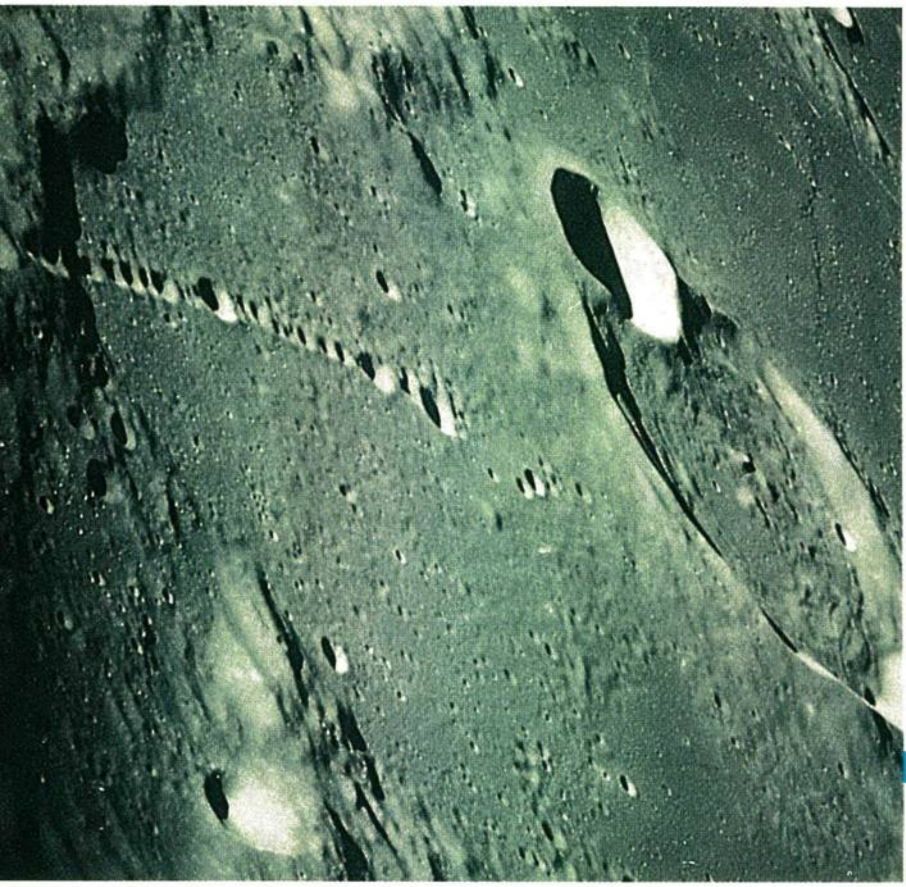
GIANT GLOWING ARCS are visible in images made recently with the ESO's 3.5-meter New Technology Telescope at La Silla, Chile. The images show distant galaxy clusters EMSS 2137–2353 (left) and 0657–5552 (right). The gravity of a giant elliptical (cD) galaxy in each cluster presumably lenses distant background objects, causing the cosmic illusions.

Great Comet Crashes on the Moon?

The Moon probably bears the impact scars of comets broken up by Earth's tidal forces, say planetary scientists Jay Melosh and Ewen Whitaker (University of Arizona) and Robert Wichman and Charles Wood (University of North Dakota). One feature both groups of scientists point to is the 50-kilometer-long Davy crater chain in Mare Nubium, west of Ptolemaeus on the Moon's nearside. (Sunrise over this region of the Moon occurs a little after First Quarter, and the crater chain is just visible in backyard telescopes.) A second possible impact-chain is a line of craterlets running northwest from the northern rim of Abulfeda, just east of Ptolemaeus.

The discovery of Comet Shoemaker-Levy 9 and the recognition of crater chains on Jupiter's moons Callisto and Ganymede (see AstroNews, February 1994) got planetary scientists looking for evidence of similar features on other bodies. Calculations showed that such chains are possible for the Earth and Moon, despite Earth's weaker tidal forces and the Moon's greater separation relative to the Jovian system. Key pieces of evidence for the cometary origin of the Davy chain are the largely uniform size, circularity, and spacing of the craters (similar to those laid down on Callisto) and their emplacement on the Moon's Earth-facing hemisphere.

NASA



A LINE OF CRATERS MARCHES across northern Mare Nubium toward the 35-km lunar crater Davy in this photo taken from Apollo 12.

New Chip Off the Old Red Block

A piece of Mars that sat unrecognized in a meteorite repository for the past ten years has now been identified. Found in the Allan Hills region of Antarctica in 1984, the meteorite was originally thought to be a

(continued on page 26)

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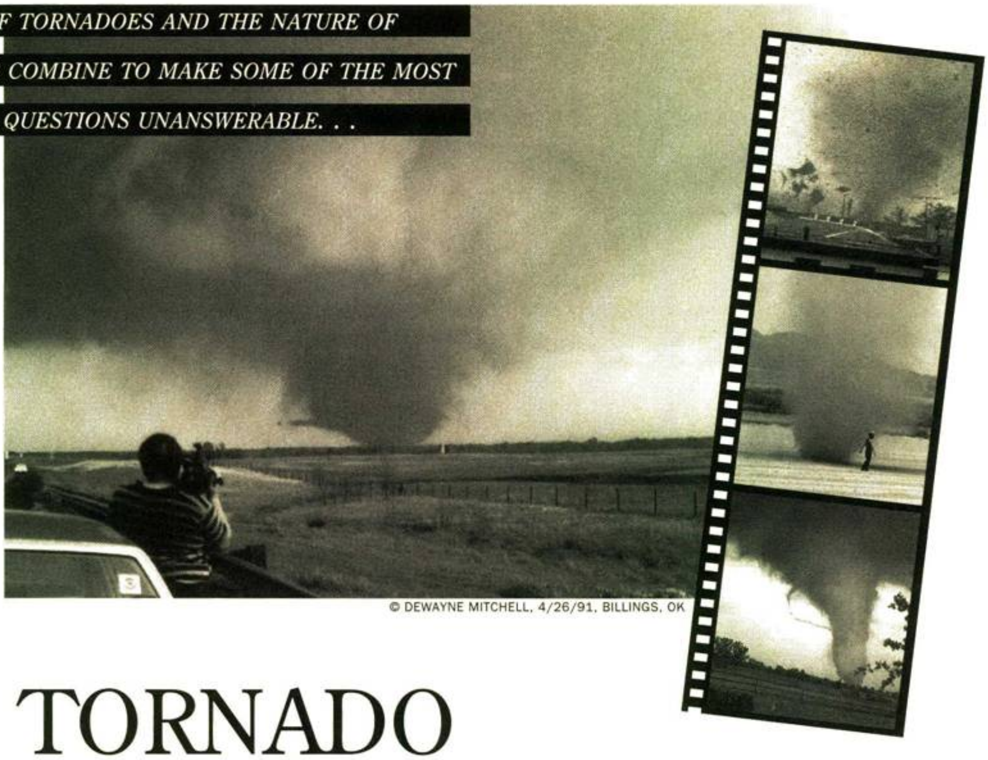

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Something for Everyone in Texas

The stars were close enough to touch at the 13th annual Texas Star Party, held May 8-14, 1994, at the Prude Guest Ranch near Fort Davis, Texas. This year's party attracted a record 851 observers, astrophotographers, and telescope makers. Besides the usual fine night skies and exceptionally interesting talks, star partiers were treated to an eclipse of the Sun on May 10.

Since the Prude Ranch site was 80 miles outside the path of annularity, a side trip was organized to view and photograph the eclipse from Sierra Blanca, some 30 miles inside the eclipse path and 45 miles from the centerline. Meanwhile, back at the ranch, viewers experienced an eclipse of 90 percent.

Well into the event a television crew from a Dallas/Fort Worth NBC affiliate showed up at the ranch looking to land some interesting video. Quick thinking on the part of TSP organizers produced a pinhole solar viewer made from a Froot Loops cereal box. The contraption appeared that night on network news from coast to coast.

But it is TSP's reputation for dark, transparent night skies that draws people year after year, and 1994 was no exception. This year observing chairman John Wagoner organized two observing programs that ran the duration of TSP, one for binoculars and the other for telescopes. Each program had a list of 25 targets. Successful completion of either program entitled the observer to a lapel pin and certificate. Twenty-five people completed the binocular list, while 59 finished the telescope program; 14 did both lists.

Dotting three observing areas were a multitude of telescopes, ranging in aperture from three inches to a whopping 37 inches. Wisconsin observers Lew Haberly and Doug Richter drove over 24 hours to observe with their 20-inch and 17-inch scopes. Both routinely saw reddish hues in summer Milky Way emission nebulae like the Lagoon and Omega and found going for faint Abell galaxy clusters a breeze. When it came to observing faint fuzzies, Houston's Larry Mitchell and his 37-inch Dobsonian wowed deep-sky aficionados with obscure galaxies pushing 18th magnitude.

SOME OF THE 650 PEOPLE who attended this year's Texas Star Party gather for a formal group photo.

ASTRONOMY: John Shibley

During the day, talks covered a wide range of topics. Florida amateur Tom Clark shared photos and stories from his recent trip to Australia, along with anecdotes about hauling a 20-inch scope halfway around the world. English deep-sky observer Owen Brazell presented a humorous overview about what it's like to observe from rainy, light-polluted England ("We sometimes have to travel to foreign countries like Wales and Scotland . . . ."). Houston observer Dennis Webb showed off a map of the Virgo Cluster he drew that portrays galaxies down to 15th magnitude. On Friday evening, galaxy expert Paul Hodge of the University of Washington in Seattle gave a talk on the history of Andromeda Galaxy studies and what current thinking is about the nature of its nebulae and open and globular clusters. According to Hodge, there is ongoing debate as to the nature of the galaxy's spiral arms. Astronomers are also discovering that some of M31's emission nebulae are less luminous than any we find in the Milky Way.

Next year's TSP will take place May 20-27 at the Prude Ranch. For a registration packet, write Keith Shank, TSP Registrar, 1226 Mistywood, Allen, TX 75002.

Antique-Telescope Enthusiasts Gather

With brass telescopes in tow, members of the Antique Telescope Society (ATS) held their second annual meeting in Williams Bay, Wisconsin, on October 23 & 24, 1993, literally a stone's throw from the historic 98-year-old, 40-inch Yerkes Observatory refractor. Antique telescope enthusiasts and history buffs were treated to talks, displays of antique telescope paraphernalia, and private tours of the Yerkes Observatory.

The weekend meeting kicked off with a presentation by Peter Wlasuk on the 19th-century astronomer Lewis Swift, made famous by the discovery of Comet Swift-Tuttle, parent comet of the Perseid meteor shower. John Hurtheres followed with a talk detailing his restoration of Swift's 16-inch refractor, which is in use at the Ricard Memorial Observatory in Santa Clara, California. Evening speaker Ron Maddison, professor emeritus from the University of Keele, England, told how he dismantled, moved, and restored a large Grubb refractor. After dinner the group was treated to a private tour of Yerkes, which culminated with an observing session using the 40-inch refractor.

On Sunday John Briggs and John Allseits described their efforts to relocate the U.S. Naval Observatory's 15-inch astrograph and 8-inch guide scope. The equipment will be stored at Yerkes until it can once again be used for tracking asteroids and faint comets. Mike Reynolds updated Chabot Observatory's plans to relocate its 20-inch Brashear refractor to an "earthquake proof" area in the California mountains. The Oakland-based observatory also wants to construct a 36-inch reflector at the new site. Richard Dreiser gave a Yerkes Observatory retrospective (which will celebrate its centennial in 1996), complete with rare construction photos .

The 1994 ATS meeting will be held October 21 through 24 at the University of Santa Clara in California. For more information, contact Walter H. Beyer, 30 Green Valley Road, Wallingford, PA 19086. — *Gregory Gonia*

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(continued on page 29)

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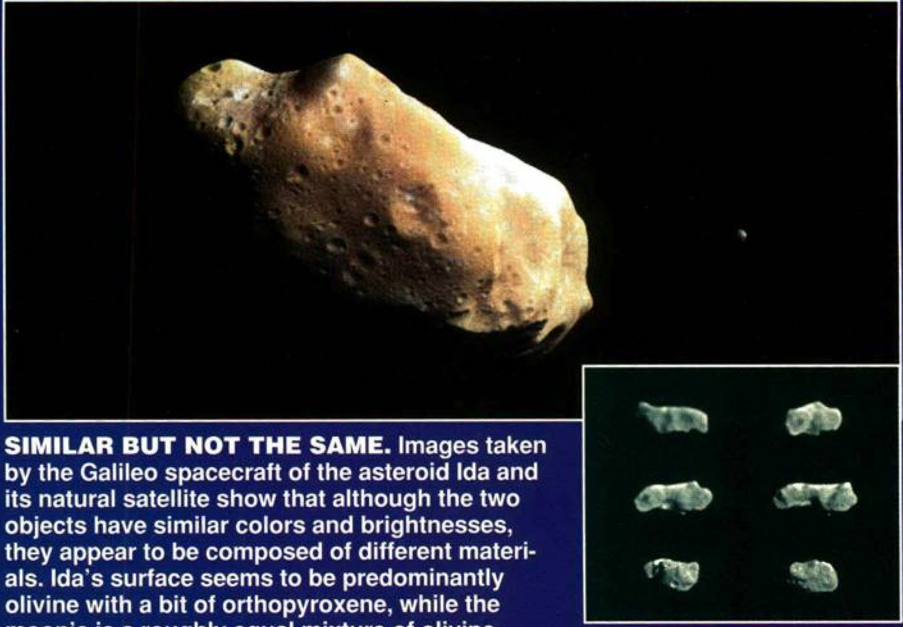
diogenite, a rock believed to come from the asteroid 4 Vesta.

But when David Mittlefehldt of Lockheed Engineering and Sciences Co. studied the meteorite's chemical and mineralogical composition, it didn't match any diogenite known. What it did match, however, was the nine meteorites suspected of coming from Mars.

"We hope this rock will tell us much more about Mars' igneous history," says Mittlefehldt. The meteorite, designated ALH84001, appears to have formed under conditions a little different from those shown by other Mars meteorites.

"The rock's texture indicates that it did not form at the surface, but at some depth, although we don't yet know how far down. It has bubbles in it that contain carbonate minerals, and when we're finished these may tell us about the early Martian atmosphere."



NASA/JPL

SIMILAR BUT NOT THE SAME. Images taken by the Galileo spacecraft of the asteroid Ida and its natural satellite show that although the two objects have similar colors and brightnesses, they appear to be composed of different materials. Ida's surface seems to be predominantly olivine with a bit of orthopyroxene, while the moon's is a roughly equal mixture of olivine, orthopyroxene, and clinopyroxene. The color image (above) shows the asteroid from 10,500 km away while the composite (right, from upper left to lower right and all at the same scale) displays 3.3 hours of its rotation as the right-hand edge moves toward the observer.

Fast-Flying Pulsars and Gamma-Ray Bursts

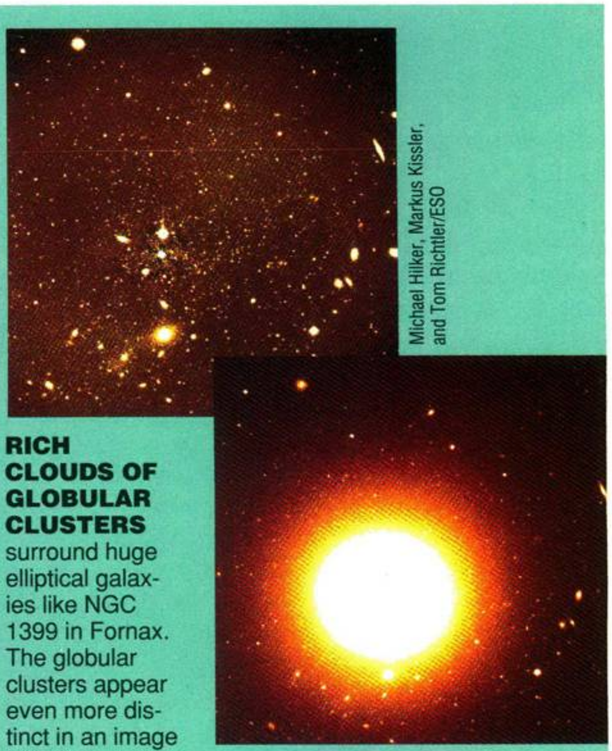
Many pulsars are born with a hard enough kick to send them flying out of the Galaxy, say astronomers Andrew Lyne and D.R. Lorimer at the University of Manchester in England. Pulsars are the rapidly rotating neutron stars born when a massive star explodes as a supernova.

If the supernova explosion is not perfectly symmetrical — and none are, say Lyne and Lorimer — then it will give the pulsar a powerful kick, sending it racing off in some direction. The researchers (writing in the May 12, 1994 *Nature*) have surveyed the apparent proper motions of 86 pulsars and found their average velocity is 450 kilometers per second. But this is actually just a minimum value since it represents merely the motion at right angles to the line of sight; pulsars' real, 3-dimensional velocities in space must be faster still because it will include some motion toward or away from Earth.

Velocities as high as these exceed the escape velocity of the Milky Way Galaxy itself. The result, Lyne and Lorimer conclude, is that about half of all pulsars eventually flee into intergalactic space. The remainder will coast out to form a large, loose, spherical halo surrounding the Galaxy. Lyne and Lorimer point to gamma-ray bursts, which come from all directions about equally, and suggest that this far-flung halo of pulsars may be the source for the bursts.

Play it Safe — Don't Get Lazed

Shuttle mission STS-64, to be launched as early as September 9, will be carrying a laser experiment to conduct atmospheric research. Three lasers aimed from the payload bay toward Earth will be fired ten times a second, illuminating



Michael Hilker, Markus Kissler, and Tom Richtler/ESO

RICH CLOUDS OF GLOBULAR CLUSTERS surround huge elliptical galaxies like NGC 1399 in Fornax. The globular clusters appear even more distinct in an image with the galaxy's light subtracted from it (top), recently made with the 2.2-meter telescope at the European Southern Observatory in Chile by Michael Hilker, Markus Kissler, and Tom Richtler.

Why elliptical galaxies contain many more globulars than do spirals is not yet known: Some astronomers believe that giant ellipticals may be the result of mergers of smaller spirals and, thus, over time accumulate a large number of clusters.

an 8-kilometer-long path that is 533 meters wide along the shuttle's ground path. One of the lasers, which emits green light, has enough energy to cause NASA concern over those who might try to observe the shuttle in flight.

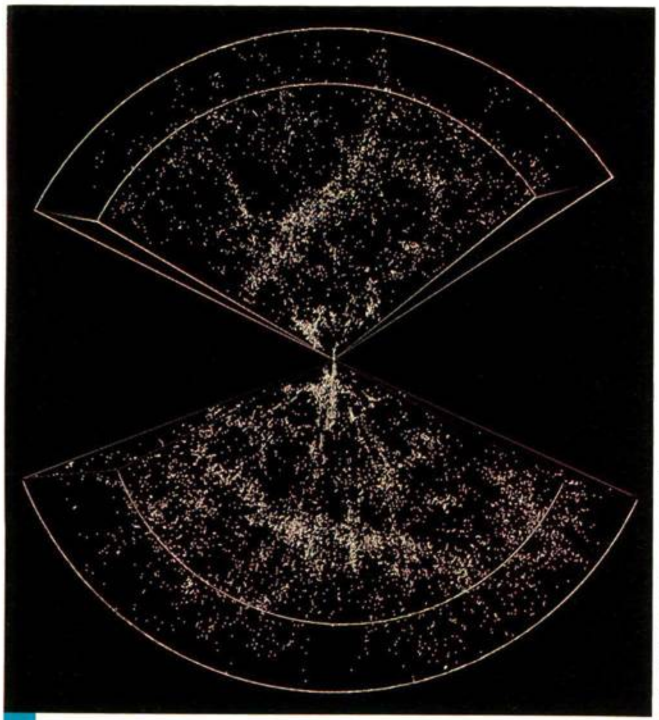
The agency has discovered that the laser beam's intensity, as viewed through large-aperture scopes, could slightly exceed federal safety guidelines, which could lead to eye damage. Consequently, NASA recommends that observers refrain from looking at the shuttle with telescopes that have apertures greater than six inches. Viewing the spacecraft with the unaided eye or binoculars should pose no hazard, nor will taking photos.

Information on the shuttle's visibility over major North American cities can be obtained by calling NASA's Space Shuttle Hotline at (713) 483-5111.

Bubbles and Voids

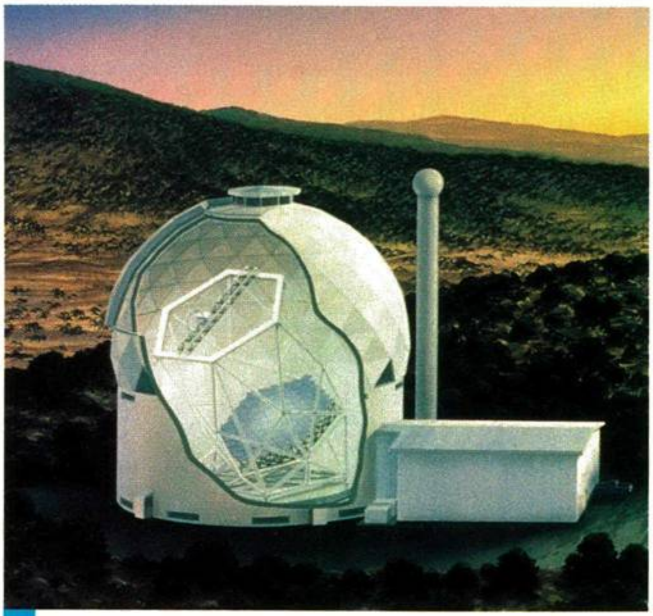
A map of more than 10,000 galaxies in the northern sky has long shown that galaxies seem to lie in sheets that surround bubble-like voids. Now a survey of 3,600 galaxies in the southern sky has extended the map of galaxies to a full third of the sky. This new survey headed by Luis Nicolai da Costa of the Brazilian National Observatory removes any concern astronomers had that voids are unique to the northern sky. "One always worries that you've seen something unique or peculiar to one area of the sky," says Margaret Geller, a member of the team who works at the Harvard-Smithsonian Center for Astrophysics in Boston, Massachusetts.

The voids aren't insignificant. They stretch over hundreds of millions of light-years, revealing the largest structures of the universe now known. Researchers don't know how these features formed, nor are they sure these are the largest structures in the universe. Geller explains, "We simply haven't explored a large enough volume of space to know if the distribution of matter in the universe is really this inhomogeneous on all scales. We are still in our own astronomical backyard." The new generation of large telescopes may enable astronomers to look deeper into the universe to search for larger structures.



Emilio Falco, Center for Astrophysics

A NEW MAP CONFIRMS researchers' ideas about how galaxies congregate in the universe. Bubble-like voids appear throughout the map and may be the largest structures in the universe. Earth lies at the center of this plot and the blank wedges mark where the plane of our Milky Way Galaxy obscures our view of distant galaxies.



University of Texas

UNLIKE CONVENTIONAL SCOPES, the Hobby-Eberly telescope under construction in Texas will always look 55° above the horizon and use a special tracker to follow an object across the sky.

Hobby-Eberly Telescope Started

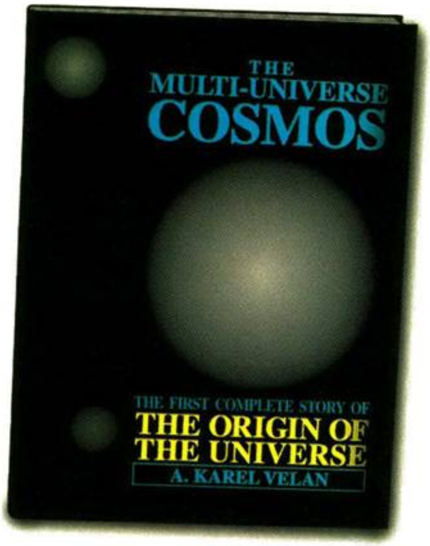
March 25 marked the groundbreaking ceremony for the latest 10-meter-class telescope, previously called the Spectroscopic Survey Telescope. It is being built in Texas at McDonald Observatory on Mount Fowlkes, which is adjacent to Mount Locke, the site of the observ-atory's other telescopes.

The telescope's 11-meter primary mirror consists of 91 one-meter segments. It will be permanently locked at an angle looking 55° above the horizon. From this position it will see 70 percent of the sky. A conventional mount would move the entire scope to follow an object during an observation, but the Hobby-Eberly telescope will rotate to the star only at the beginning of the exposure. The mirror will then remain fixed. A special tracker mounted above the mirror will follow the object and send its light down a fiber-optic cable to a spectrograph in a room below the telescope. The spectrograph will break the object's light into its component colors, enabling astronomers to measure the object's motion, determine its chemical nature, and ascertain its temperature.

Construction workers will finish the scope and the observatory in late 1996. During the following year, astronomers will install and test the instruments and start their observing in late 1997. The telescope will be operated by three U. S. and two German universities: the University of Texas, Pennsylvania State University, Stanford University, Ludwig Maximilian University in Munich, and Georg-August University in Göttingen.

(continued on page 30)

An intriguing new theory on the birth of the universe!



A.K. Velan, an Engineer-industrialist with a profound, lifelong interest in cosmology presents a pioneering new theory on the birth of our universe within a Multi-Universe Cosmos. The new model probes further into the past than anyone has previously ventured, explaining the origins of Matter and radiation, breaking through the theoretical constraints of the Big Bang, Singularity Model and filling in the gaps in our understanding of the universe.

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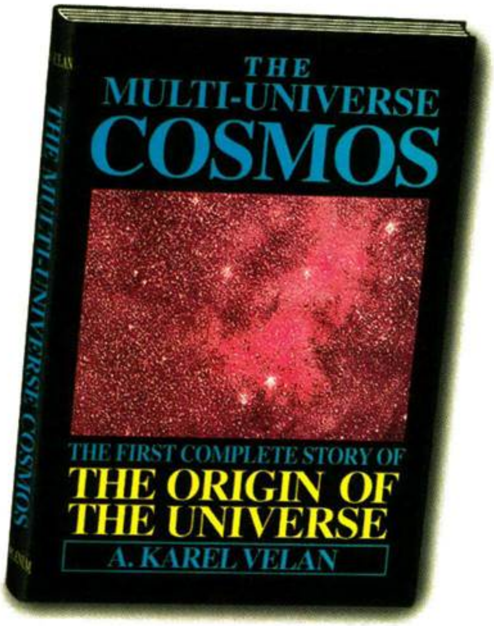

"This is a remarkable and – in my experience – a unique book. Science graduates and lay persons alike will enjoy A. Karel Velan's attractive and very readable account of the basic physics underlying the challenge of cosmology, which occupies the first half of ***The Multi-Universe Cosmos***. It is, however, in the remainder of the book where the author makes his unique contribution. Here Velan develops his own theory of the origin of the universe. . . This book will provide a fascinating and thought-provoking study. . . It represents a truly remarkable personal achievement."

– Kenneth A. Pounds, **Department of Physics and Astronomy, University of Leicester, Leicester, United Kingdom**

"The author of ***The Multi-Universe Cosmos*** does a good job making clear what it is about conventional models of the early universe that is likely to bother most people."

– Virginia Trimble, **Department of Physics, University of California, Irvine; Astronomy Program, University of Maryland, College Park: and Editor, *Comments on Astrophysics***

"Karel Velan's book is a remarkable achievement."

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FOR SALE. Edmund Astroscan 2001 with all accessories plus 8 mm and 15 mm eyepieces and 2X Barlow lens. Excellent condition; $250. Contact Tom Seaman, 718 Fishing Creek Rd., New Cumberland, PA 17070, (717) 938-9685.

FOR SALE. Rare copies of the *Planetary Report* and other Sasakawa International Center for Space Architecture publications. Profits help teach prison inmates about the universe. Contact John Brown Ph.D., c/o The Planetary Society, Huntington Prison, 1100 Pike Street, Huntington, PA 16654-1112.

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(continued on page 101)

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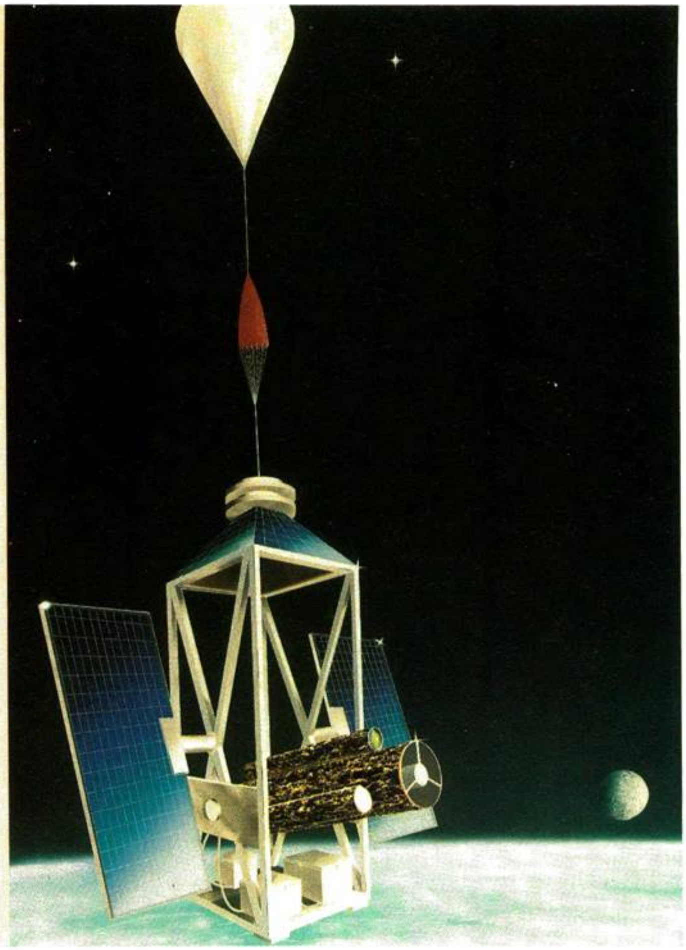
Buckyballs Found in Space

Residues of two exotic carbon molecules have been found in an impact crater on an Earth-orbiting satellite. The molecules, C60 and C70, are buckminsterfullerenes, or "buckyballs" for short, a name that derives from their molecular structure which resembles a geodesic dome. A team of planetary scientists led by Filippo Radicati di Brozolo of Charles Evans & Associates of Redwood City, California, report the finding in the May 5, 1994 issue of *Nature*.

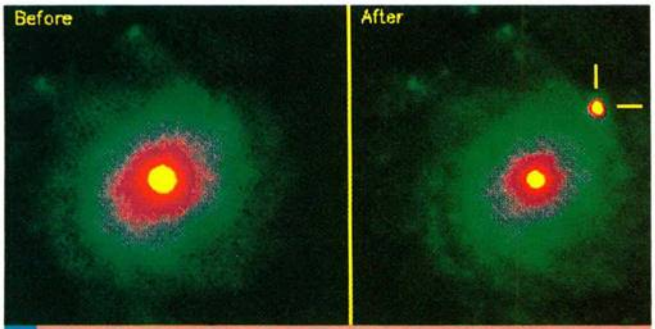
Buckyball molecules are found on Earth and are suspected by astronomers (on spectroscopic grounds) to exist in interstellar clouds. Yet until now no one had found conclusive evidence for them in space or in meteorites.

The molecules were part of a tiny chondritic meteorite that struck the Long Duration Exposure Facility (LDEF) satellite sometime between its lauch in April 1984 and its retrieval in January 1990. The 30-foot-long satellite was designed to record impacts from particles orbiting the Sun and Earth as well as any traveling through the solar system from outside (see "Motes in the Solar System's Eye," May 1993). The team reports that the size of the crater and LDEF's orientation suggest that the impactor was traveling at a relatively slow speed (about 13 kilometers per second) and so was unlikely to have come from outside the solar system.



CRUISING 125,000 FEET OVER THE SOUTH POLE, a balloon-borne Flare Genesis solar observatory will map the Sun's surface magnetic field at ten times the resolution of ground-based instruments. Once launched from Antarctica's McMurdo Station in December 1994, the two-ton observatory, built by the Johns Hopkins University Applied Physics Laboratory, will stay aloft at least 11 days studying the Sun with high-resolution instrumentation attached to a 32-inch telescope. The telescope's mirror, originally built for ballistic missile defence experiments, was donated to the project by the Air Force.

The Johns Hopkins University Applied Physics Laboratory



SUPERNOVA 1994I IN THE WHIRLPOOL GALAXY (M51), shown here before (left) and after (right) the explosion, continued to fade slowly in optical light through May. But this rare type Ic supernova evolved much faster at radio wavelengths. Although the supernova's radio emission was first seen on April 3, just one day after its visual discovery, it had faded from view by April 16. That confirms previous observations of both type Ib and Ic supernovae, which had shown similar rapid declines.

P. Challis, O. Kuhn, and B. Schmidt/Harvard-Smithsonian Center for Astrophysics

Solving the Hyades Problem

The cluster of stars in the constellation Taurus known as the Hyades has long presented a puzzle. Astronomers expect that all the cluster stars, because they formed from a single gas cloud, should have the same lithium abundance. But in the Hyades, the amount of lithium decreases rapidly from warmer to cooler stars.

Because the amount of lithium in a star correlates with its age, astronomers hoped to use the well known age of the Hyades as an calibrator for finding ages using lithium abundances. Theorists have offered various explanations for the Hyades lithium problem such as the burning of lithium by stars early in their life cycles. Cool stars spend more time in this early phase than do warm ones and presumably would burn more lithium. But the models can't explain the observed depletions.

A revision of this idea blames the Hyades problem on oxygen — enhanced oxygen levels in the Hyades compared to most other stars enhances lithium burning. New models that predict lithium abundances including the effects of higher oxygen amounts agree with observed lithium abundances quite well. Fritz Swenson of the University of Victoria in British Columbia and his colleagues presented their resolution of the Hyades problem in the February 20, 1994 issue of the *Astrophysical Journal*. □

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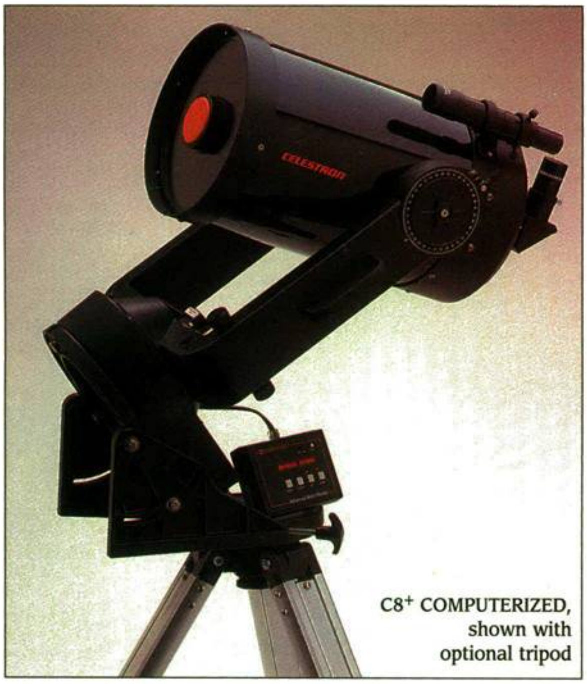

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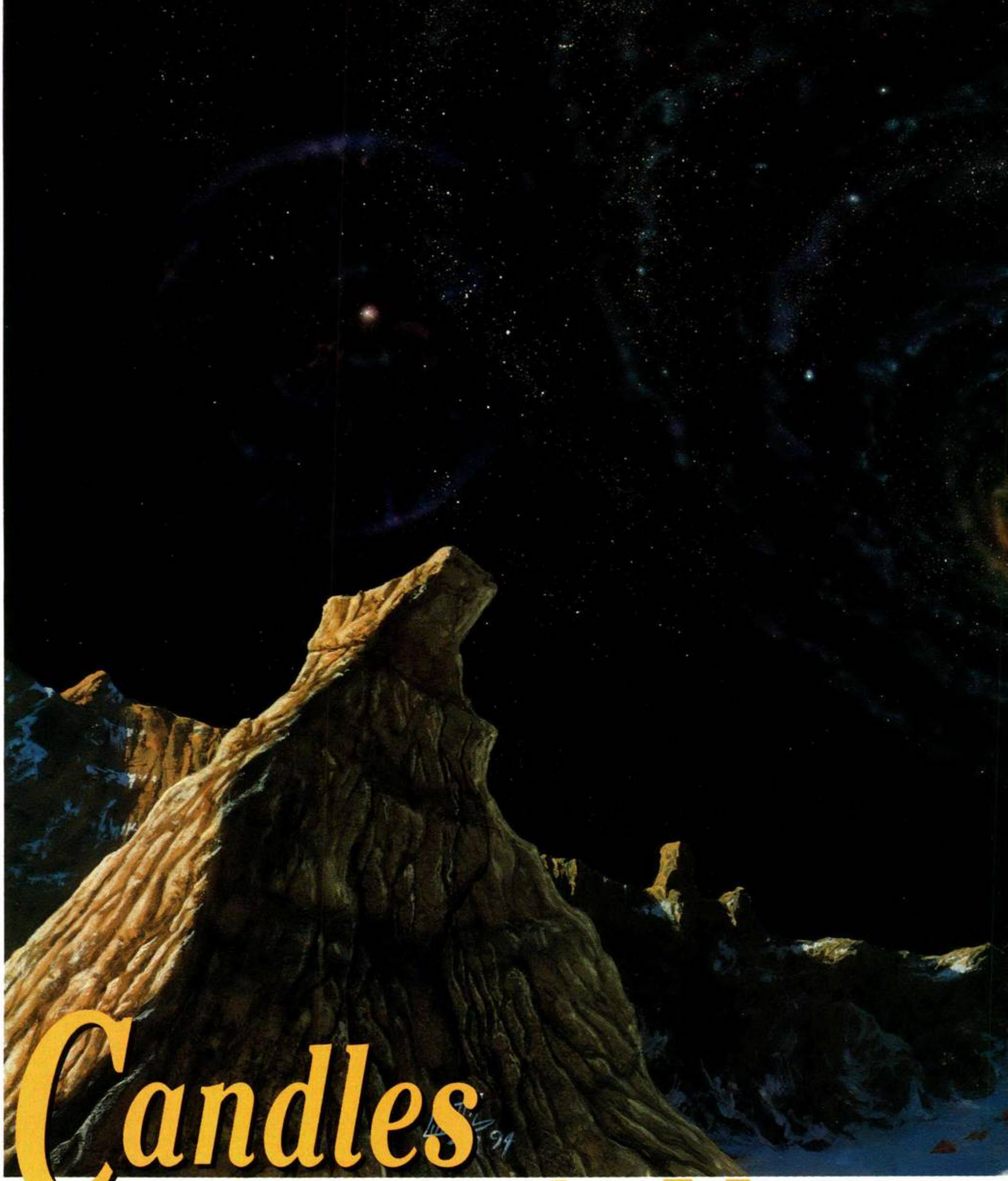
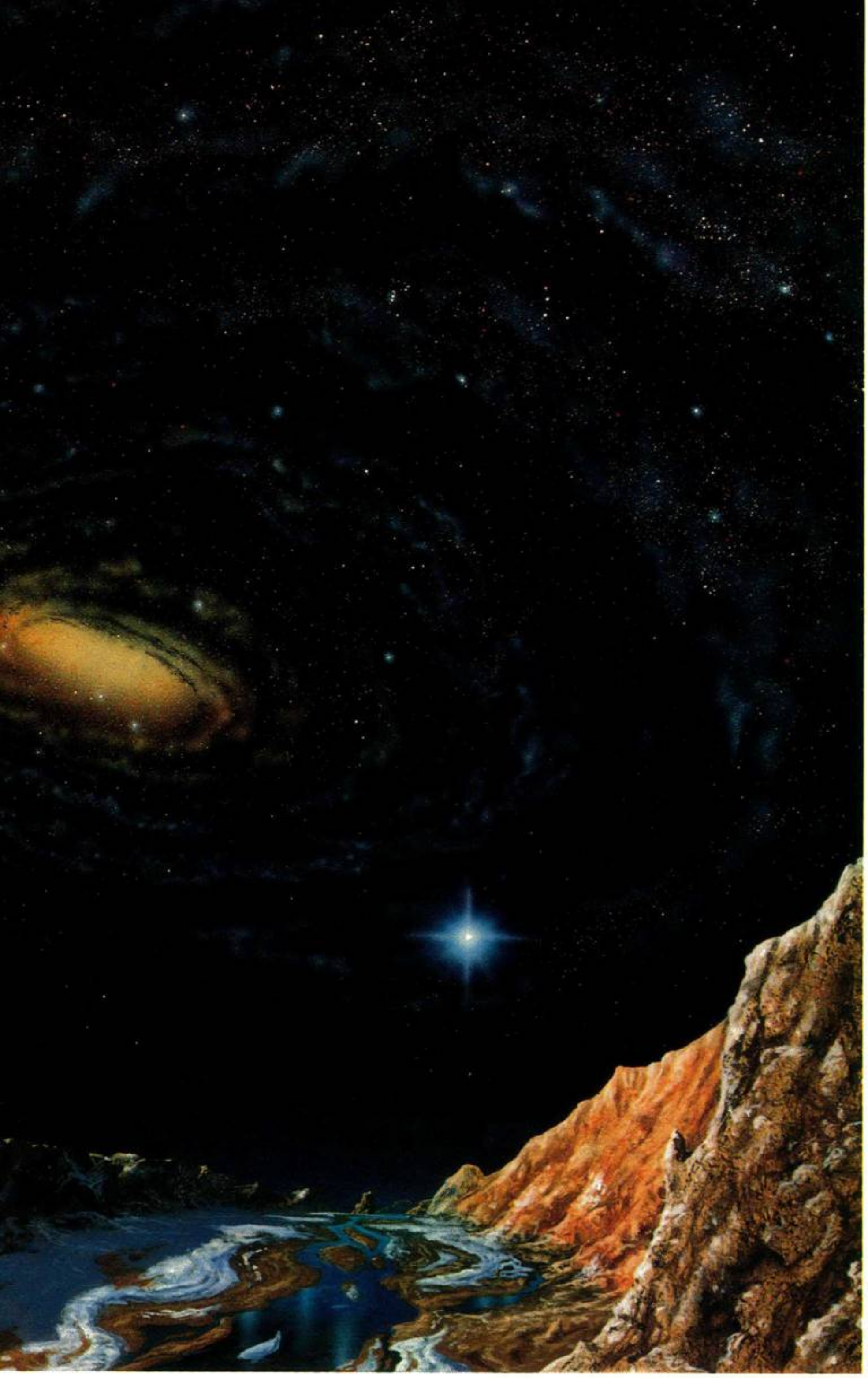


Candles to Light the Night



Michael Carroll

The size of the universe is about to change, thanks to breakthrough work by the repaired Hubble Space Telescope and exciting new methods of measuring cosmic distances.

by David J. Eicher

How big is the universe? It's a simple question that lacks a simple answer. Astronomers have struggled with this query for decades, and they are only now drawing toward a conclusion.

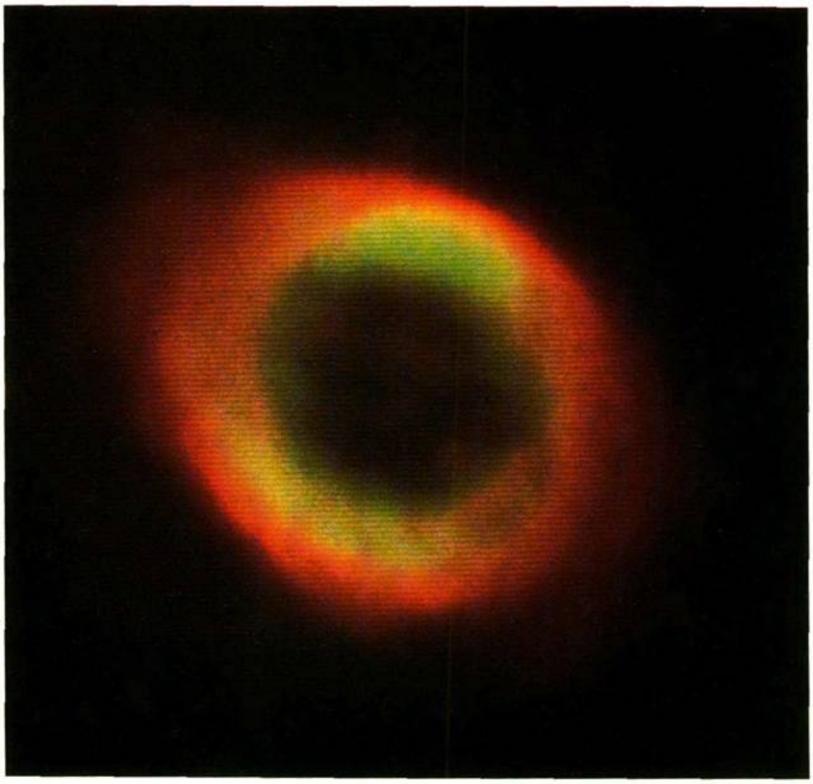
To measure the universe, they use a battery of what they call "standard candles," objects of well-known brightness that act as cosmic yardsticks. The method dates back a century but came into prominence when the American astronomer Edwin Hubble accomplished his landmark research of the 1920s.

In 1923 Hubble used a relationship between Cepheid variable stars' brightnesses and their periods of variability to measure the distance to the Andromeda Galaxy. (Astronomers had already found that a Cepheid's luminosity depends on its period: the longer the period, the greater the star's brightness.) Hubble's research proved not only that galaxies were separate islands of stars outside the Milky Way but also that Cepheids were reliable as standard candles over large distances.

Six years later Hubble established the Hubble Law, which characterizes the expansion of the universe after the Big Bang. The law says that the recession velocity of an object is proportional to its distance, and the relationship is governed by a number called the Hubble constant (H_0) measured in kilometers per second per megaparsec. The Hubble constant, then, controls the size and age of the universe.

Due to its importance, this one lonely number has unleashed a firestorm of debate. A relatively high Hubble constant suggests a rather small, young universe that stretches 8 to 12 billion light-years across and began 8 to 12 billion years ago. A low Hubble constant, however, implies a larger, older universe spanning 15 billion light-years or more and beginning 15 or more billion years ago.

But whatever the size and age of the universe turn out to be, finding the distance scale of the universe —the



Bruce Balick, University of Washington

Cast Off by Dying Stars

Planetary nebulae have come to the forefront as reliable distance indicators. Objects like the Ring Nebula (M57), located in distant galaxies, are helping astronomers measure the size of the cosmos.

distances between galaxies and galaxy clusters — is a hotbed of astronomical research. Today's work continues Hubble's and extends far beyond it. Cepheid variable stars remain the pre-eminent standard candles because their predictable absolute brightness and great regularity in light variation permit astronomers to estimate how far away they are. Knowing how bright a light is in absolute terms, it's easy to calculate the distance to it after measuring how bright it appears. But one standard candle cannot resolve the distance scale all by itself. Astronomers need other methods. These include observing another kind of variable star called RR Lyrae stars, measuring the brightness and size of spiral galaxies and applying an inventive technique called the Tully-Fisher relation, and using bright objects such as supernovae and planetary nebulae as candles in distant galaxies.

Why all the varied methods? Because no single one is absolutely reliable, and all disagree in part. Some measure distances out to only a few million light-years, while others are good at measuring to tens of millions of light-years. One of the greatest challenges has been to calibrate the methods against each other and to piece together a yardstick that can measure across several overlapping ranges of distance.

The results spotlight the problem. A majority of these standard candles — including planetary nebulae, Cepheid variables, and spiral galaxies — indicate a large value for the Hubble constant. They suggest that H_0 may be 75 to 90 kilometers per second per megaparsec, which points toward a smaller, younger universe. The conflict comes when astronomers look at Type Ia supernovae, important distance indicators that appear to be credible and thoroughly understood. But these yield a much lower Hubble constant, 50-60 km/sec/Mpc, which suggests a much larger and older universe — larger and older by 50 percent. Clearly one side is wrong — or maybe the answer lies in between.

If astronomers can get these techniques working together, standard candles may provide an absolute distance scale of the cosmos and in so doing indicate not only the size, age, and expansion rate of the universe but perhaps its eventual fate as well. The quest for these big answers, however, has come into sharper focus only in the past decade, with new techniques and new candles.

Planetary nebulae provided a significant new approach to measuring distances in the early 1980s as astronomers began discovering lots of them in other galaxies. A planetary nebula is the slowly expanding shell of gas cast off from a dying star (see "Ashes to Ashes and Dust to Dust," May 1994). Planetaries are now the central focus of research for George Jacoby of the National Optical Astronomy Observatories. He has led a revolutionary effort to study extragalactic planetaries, which are three to four times more numerous than those known in our own Galaxy.

His approach was novel from the outset. Without bothering to study planetaries individually, Jacoby began to use large telescopes and state-of-the-art imaging technology to study their statistical properties. Knowing a good deal about the brightness of planetary nebulae in the Milky Way, the Magellanic Clouds, and the Andromeda Galaxy, Jacoby and his colleagues used these averaged nebulae as yardsticks to estimate distances to other galaxies in the universe.

At first the progress was slow. In the late 1970s, astronomers Holland Ford and David Jenner used the 4-meter telescope on Kitt Peak and a digital detector to locate eight planetaries in the galaxy M81, an object about 10 million light-years away. Now, however, Jacoby has cataloged planetaries in galaxies nearly 60 million light-years distant, beyond the Virgo Cluster of galaxies. The team used the nearby Andromeda Galaxy (M31) for calibrations because its distance of 2.2 million light-years was well known (from the study of Cepheids and other indicators) and because its planetaries could be easily compared in brightness to those in more distant galaxies.

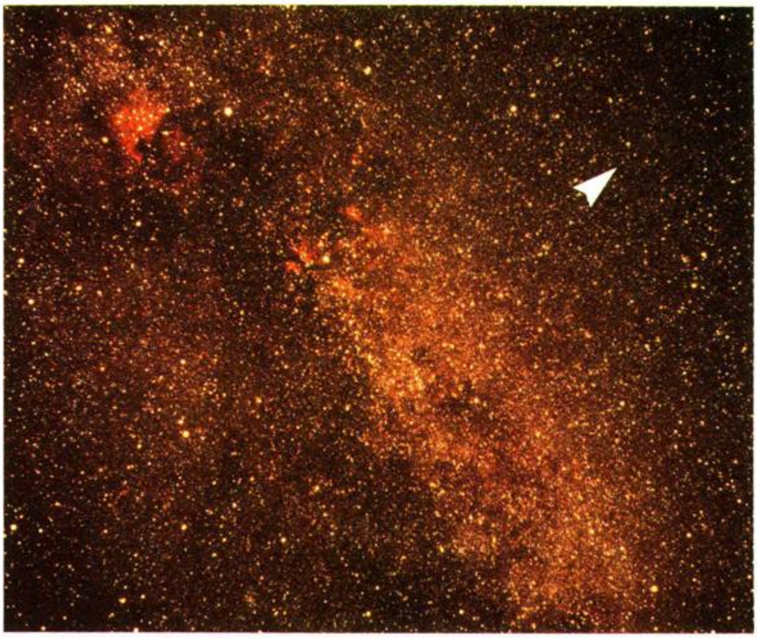
Their calculations went like this: the planetaries in M81 appeared about 20 times fainter than those in M31. Because light grows dimmer as the square of the distance, the distance to M81 must be the square root of 20, or about 4.5 times greater than the distance to M31. Multiplying 4.5 by 2.2 million light-years yields 9.9 million light-years, a figure that agrees with distances derived using other methods.

"But relying on the very brightest few planetary nebulae was a pretty fuzzy way of getting the distance," says Jacoby. "We shelved the idea temporarily because we hadn't the resources or technology to continue it in a more sophisticated way."

The idea was revived with the emergence of CCDs in the early 1980s. "That let us find a dozen planetaries in M87, the central galaxy in the Virgo Cluster," Jacoby says. Today, they've found 55 planetaries in M87 alone, and nearly 5,000 planetaries outside the Milky Way in total — three times as many as astronomers know of in our own Galaxy.

By the mid-1980s Jacoby and his colleagues had evolved a more rigorous method. They compared the planetaries of a particular brightness in a given galaxy with those of a closer galaxy. "When we look at a galaxy, we see a small number of very bright planetaries, many more that are fainter, and lots that are fainter yet," says Jacoby. "You count the numbers of planetaries of each brightness and you compare them with those in closer galaxies to gauge the galaxy's distance to a fairly high degree of accuracy. The key is to sample enough planetaries in a galaxy to make the process meaningful."

The results agree with the more traditional ways of measuring distances to galaxies using Cepheids and RR Lyrae stars. The behavior of these stars is so well known that their brightness in other galaxies provides a relatively dependable cosmic yardstick. Planetary nebulae offer a significant advantage as standard candles, however, in that they work in elliptical galaxies, which do not contain Cepheid variables and are generally so distant astronomers can't detect their RR Lyrae stars.


Brian Tkachyk

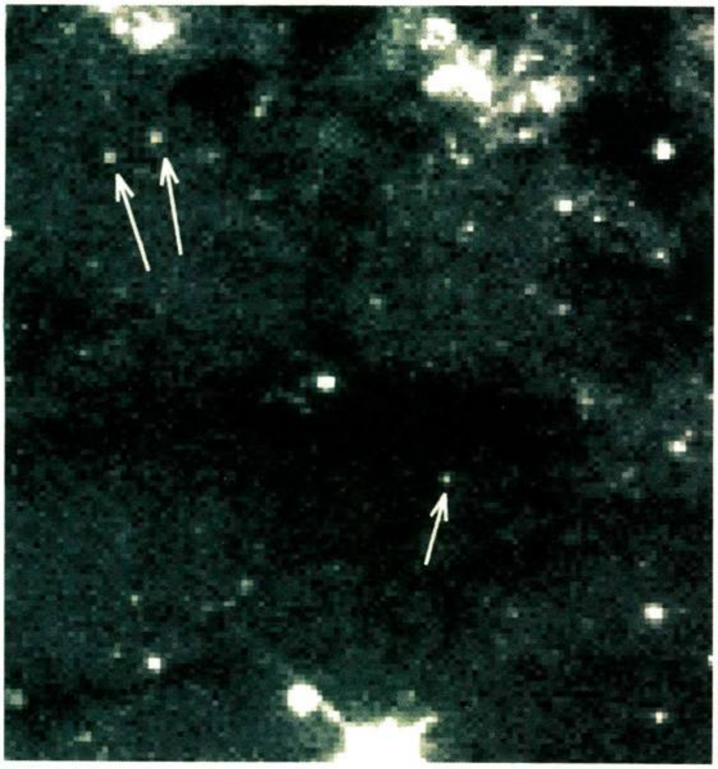
A Cosmic Needle in a Haystack

Variations in the star RR Lyrae (arrow) permit astronomers to measure its distance accurately. Similar stars in relatively close galaxies help pin down the distances to those objects.

Cepheid variables remain the most reliable candle. "Edwin Hubble broke open the Cepheid distance scale by showing that these variable stars in other galaxies like the Andromeda Galaxy and NGC 6822 were the same kinds of objects as those we see nearby," says Barry Madore of the California Institute of Technology. Madore sees not only the historical importance of Cepheids, but also their future significance: He is one of a team of scientists (led by Wendy Freedman of the Carnegie Observatories, Rob Kennicutt of Steward Observatory, and Jeremy Mould of Siding Spring Observatory) currently using the Hubble Space Telescope to observe Cepheids in the Virgo Cluster.

"Over and over again," he says, "Cepheids have proven the most credible means to establish distances to relatively nearby objects. Moreover, other methods such as planetary nebulae and the Tully-Fisher relation depend on Cepheids to calibrate them. Without Cepheids, astronomers would be in a real quagmire."

Calibration is critical. Astronomers use Cepheids in the Milky Way and in relatively close galaxies to support other methods that reach deeper into space. "If Cepheids are


NASA/Hubble Space Telescope

Cepheid Variables

These faint stars in the galaxy M100 (arrows) may hold the key to the distance scale of the universe. The Hubble Space Telescope will soon start observing them to learn their distances.

screwed up," says Madore, "all the other methods are carried along with them."

But Cepheids do not appear screwed up. They've been observed thousands of times and astronomers rely on them.

"The beauty of Cepheid variables is that they're controlled by gravity alone," says Madore. "They couldn't be simpler from a modeling standpoint. Gravity controls the motions of the stars' atmospheres as they pulsate, and the natural timescale of those motions is as straightforward as that of a pendulum. That, in addition to the simple physics of temperature and surface brightness, provides a clear understanding of what the stars are doing. Theorists and observers walk hand in hand when it comes to these variables."

If any new uncertainty about Cepheids emerges, astronomers can reobserve the very same stars that Edwin Hubble looked at, checking the historical accounts as they go. They can't do that with supernovae, for example. Additionally, Cepheids are numerous — they can be found in any spiral galaxy. The largest numbers of known Cepheids exist in two very close galaxies, the Large and Small Magellanic Clouds (each with 1,000), and many more Cepheids are known out to a distance of about 10 million light-years. While this is hardly in the cosmic backyard, 10 million light-years still lies within the neighborhood.

But this points up the one great limit to the usefulness of Cepheids. Because of the limited resolving power of telescopes on Earth, astronomers cannot study Cepheids in detail far enough out to really pin down the uncertainties about the distance scale. All that may change, however, with the work the Hubble Space Telescope is now doing.

RR Lyrae Stars
Old yellow variable stars called RR Lyraes help astronomers fix the distance scale in galaxies relatively close to our own. Work out to about 10 million light-years.

But astronomers will have to analyze the HST observations for many months before they reach a firm conclusion. In the meantime, they will continue using other candles to verify what planetary nebulae and Cepheids appear to tell them. For example, another longstanding approach uses RR Lyrae stars — old, yellow variables with well-known absolute brightnesses that change little with period. RR Lyraes are low-mass pulsating stars with typical periods of less than one day, much shorter than those of the Cepheids.

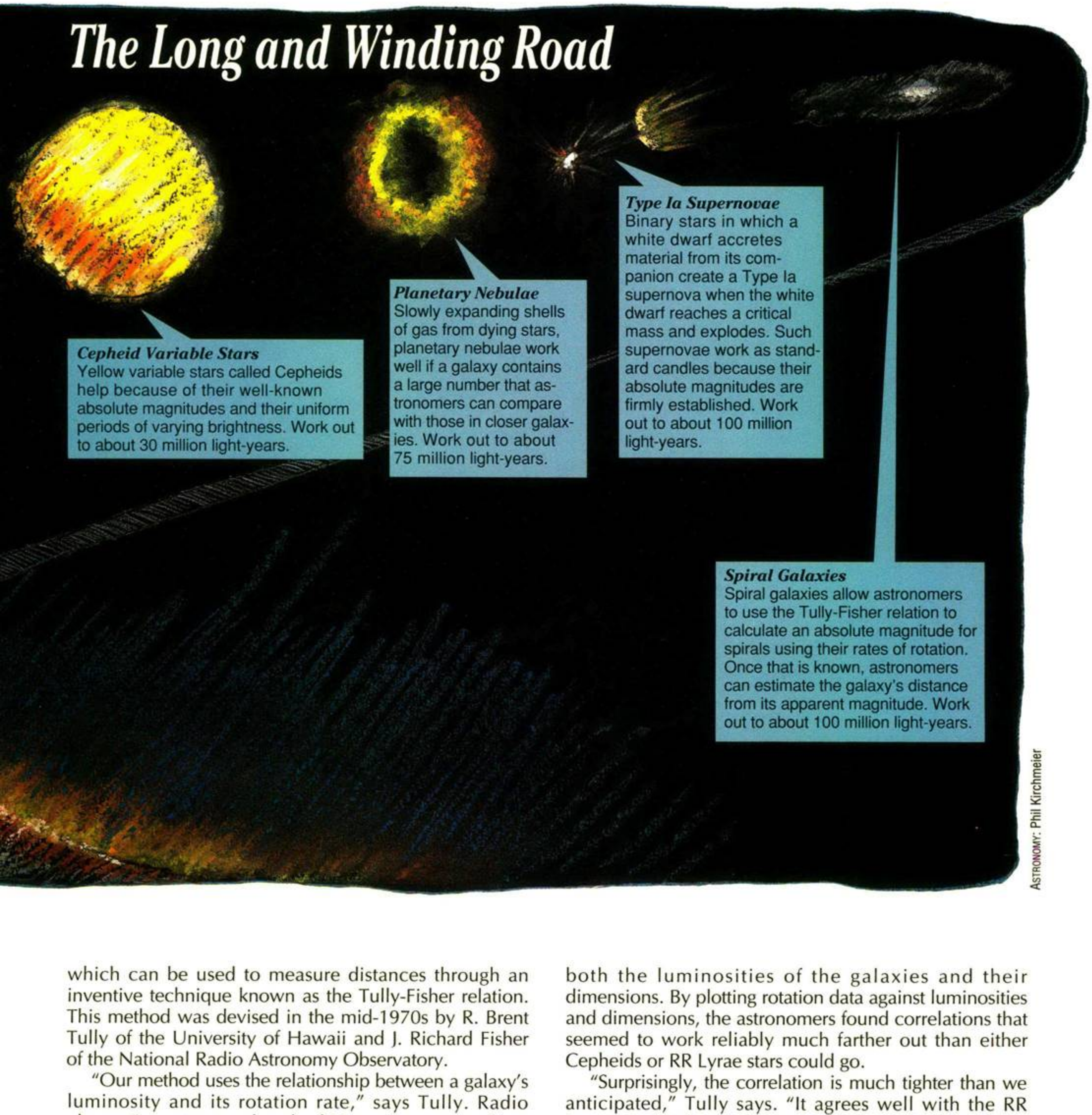
"RR Lyrae stars are very important standard candles because they are visible in places where other candles aren't," says Horace Smith of Michigan State University. Globular star clusters contain many old stars, including RR Lyraes, so these variables are useful for determining the distances to globular clusters and to nearby dwarf galaxies, which likewise contain plenty of RR Lyrae stars. Calibrating RR Lyraes from globular cluster observations allows astronomers to use them as candles in more distant objects.

"As with Cepheids, RR Lyraes offer the immensely valuable quality of allowing us to check historically observed stars with current observations," says Smith. Astronomers have observed RR Lyraes nearly as long as they have Cepheids. In the early 1890s, astronomer Solon Bailey recognized that all the RR Lyrae stars in a given globular cluster with the same period appear to have the same brightness and thus must have the same absolute magnitude. A generation later Harlow Shapley calibrated RR Lyrae stars relative to Cepheids; in the 1950s, astronomers recalibrated the magnitudes of RR Lyrae stars with those of Cepheids in a more sophisticated way.

"Two controversies with RR Lyraes have arisen over the past few years," says Smith. "The first concerns agreeing on a calibration so that astronomers know what absolute magnitude RR Lyrae stars have. The second concerns determining whether all RR Lyrae stars in fact have the same absolute magnitude." Unfortunately RR Lyrae stars are much fainter than Cepheids and work as candles only out to a distance of about 3 million light-years. This reaches only to the nearest galaxies that surround ours. But they do provide a valuable check on the other methods.

Faced with using stars that carry them to only the nearest cosmic shores, astronomers have in recent years championed other objects as standard candles. Perhaps the most promising are spiral galaxies,

The Long and Winding Road



Cepheid Variable Stars
Yellow variable stars called Cepheids help because of their well-known absolute magnitudes and their uniform periods of varying brightness. Work out to about 30 million light-years.

Planetary Nebulae
Slowly expanding shells of gas from dying stars, planetary nebulae work well if a galaxy contains a large number that astronomers can compare with those in closer galaxies. Work out to about 75 million light-years.

Type Ia Supernovae
Binary stars in which a white dwarf accretes material from its companion create a Type Ia supernova when the white dwarf reaches a critical mass and explodes. Such supernovae work as standard candles because their absolute magnitudes are firmly established. Work out to about 100 million light-years.

Spiral Galaxies
Spiral galaxies allow astronomers to use the Tully-Fisher relation to calculate an absolute magnitude for spirals using their rates of rotation. Once that is known, astronomers can estimate the galaxy's distance from its apparent magnitude. Work out to about 100 million light-years.

ASTRONOMY: Phil Kirchmeier

which can be used to measure distances through an inventive technique known as the Tully-Fisher relation. This method was devised in the mid-1970s by R. Brent Tully of the University of Hawaii and J. Richard Fisher of the National Radio Astronomy Observatory.

"Our method uses the relationship between a galaxy's luminosity and its rotation rate," says Tully. Radio observations at a wavelength of 21 centimeters provide a rotation rate for spiral galaxies. Faster rotation means the galaxy has more mass, and more mass means the galaxy is bigger and brighter. Once astronomers determine the galaxy's absolute magnitude using the Tully-Fisher relation, they estimate its distance by comparing its absolute magnitude with its apparent brightness.

"We wondered how anyone could ever calibrate the method," says Tully. "We worked the method on a number of clusters of galaxies where we could be sure that both intrinsically faint and bright galaxies were at the same distance." Initially Tully and Fisher observed spirals in the nearby Virgo and Ursa Major clusters. Along with the rotation data, Tully and Fisher measured both the luminosities of the galaxies and their dimensions. By plotting rotation data against luminosities and dimensions, the astronomers found correlations that seemed to work reliably much farther out than either Cepheids or RR Lyrae stars could go.

"Surprisingly, the correlation is much tighter than we anticipated," Tully says. "It agrees well with the RR Lyrae, Cepheid, and planetary nebula methods, and this gives us confidence that we are all on the right track."

In addition to the Tully-Fisher method, astronomers have pioneered another approach that uses galaxies as candles. Over the past six years John Tonry of the Massachusetts Institute of Technology has pushed forward the surface brightness fluctuation method. This creative technique uses the fact that distant elliptical galaxies appear like giant, unresolved globular star clusters. When a piece of such a galaxy is imaged with a CCD, the unresolved discrete stars cause the galaxy's surface brightness to be "bumpy" across the galaxy, and the degree of this fluctuation leads to an estimate of the galaxy's distance.

George Greaney and Mike Newton

Spiral Galaxies

NGC 2403 in Camelopardalis and other spiral galaxies allow astronomers to measure distances with the Tully-Fisher relation, which uses the galaxy's rotation period to derive an absolute magnitude and thus its distance.

All the methods we've looked at thus far point toward a high Hubble constant. But there's an important exception — Type Ia supernovae. A large number of astronomers have studied these exploding stars for many years. They have amassed both an impressive pile of observational data and straightforward theoretical models to explain the stars' behavior in detail. A Type Ia supernova is the end result of a white dwarf star that is accreting matter from its primary companion star. When it reaches a critical mass, the white dwarf explodes violently and for a brief time shines as brightly as its entire host galaxy.

Besides being reliable, Type Ia supernovae offer another advantage: They are extremely bright. Therefore astronomers can sample them deep into the universe — over distances of hundreds of millions of light-years.

But in contrast to the other methods, Type Ia supernovae point strongly toward a *low* Hubble constant and therefore imply a larger, older universe. Attempts to reconcile the Type Ia method with other standard candles has led to an impasse. Supernova researchers find themselves fundamentally at odds with astronomers pursuing the distance scale of the universe by other methods.

"The whole argument with supernovae lies in their absolute calibration," says Dave Branch of the University of Oklahoma, a Type Ia expert. "What we need to know is the absolute magnitude of at least one relatively close Type Ia supernova and then how to match it up with more distant supernovae," he says.

In calibrating Type Ia supernovae, astronomers need to understand the physics of the explosion taking place. The peak luminosity depends on how much nickel (Ni^{56}) the explosion produces. "We can get at this quantity in two ways," says Branch, "by direct spectroscopic analysis and by the kinetic energy of the explosion. The greater the nuclear fusion during the explosion, the greater the kinetic energy released, and we can measure this in the spectrum of a Type Ia supernova. If we do that we can estimate the supernova's peak luminosity, and that leads us to an estimate of the Hubble constant. When we do that we get a Hubble constant of about 50 to 60 km/sec/Mpc.

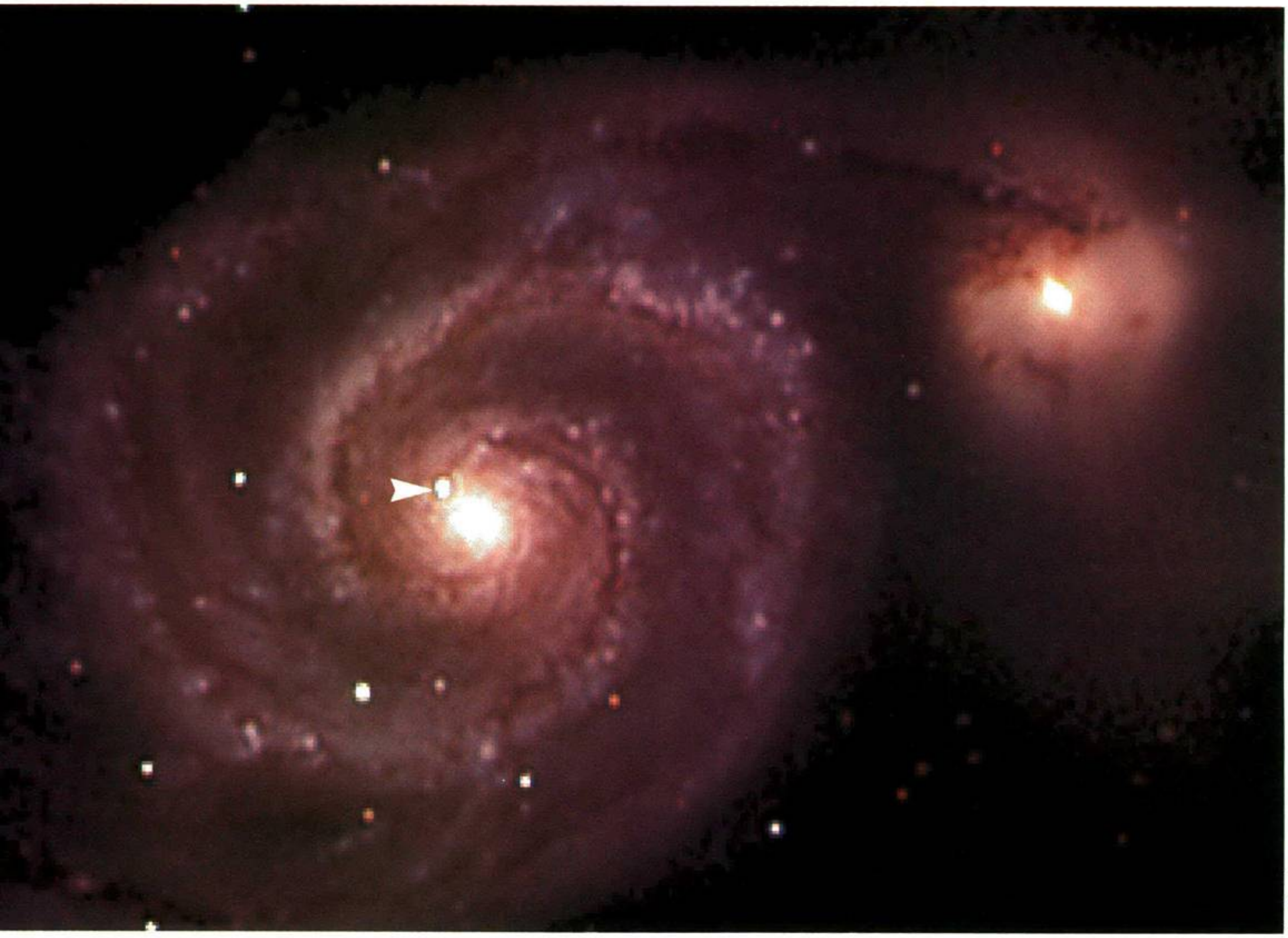
"Observationally, the evidence we have so far is that a strong majority of these stars are highly reliable," says Branch. "They're not identical. But they are very similar in spectrum, light curve, and peak absolute magnitude." A small group of Type Ia supernovae are different because they are obscured by dust, which makes them redder and fainter. Others are intrinsically fainter than average. "These supernovae differ in their spectra and colors, so they can be weeded out," contends Branch. "Despite these exceptions, we can isolate the majority of Type Ia supernovae and use them reliably as distance indicators."

In recent years astronomers like Brian Schmidt at the Harvard-Smithsonian Center for Astrophysics have focused on developing Type II supernovae as usable standard candles. Type II supernovae are created by supergiant stars that explode because they exhaust their fuel supplies and collapse inward. These stars are surrounded by a large shell of faint gas. Schmidt and others have developed a promising new method in which they observe the rate of the photosphere's expansion to gauge its distance.

This autumn, a solution to the discrepancy in results from Type Ia supernovae and the other objects may be in hand. Recently Allan Sandage of the Carnegie Institution of Washington used the Hubble Space Telescope to observe Cepheid variables in the galaxy IC 4182. Sandage then tied these observations to those of supernova 1937C, a star that exploded in IC 4182 and which has long been used by those using the Type Ia supernova approach. Sandage's research allowed astronomers interested in Type Ia upernovae to calibrate them accurately for the first time. Sandage, who pioneered the Type Ia supernova method (and who is therefore a supporter of a small Hubble constant), found that distances to Type Ia supernovae with the new calibration do *not* agree with those obtained using the other major standard candles.

"The inescapable conclusion is that either Type Ia supernovae or the other major methods are miscalibrated," says George Jacoby.

Jacoby and Mike Pierce of the National Optical Astronomy Observatories have recently reexamined the photometry of supernova 1937C. They digitized the original plates of 1937C used by astronomers Walter Baade and Fritz Zwicky to set the calibration for Type Ia supernovae. Jacoby and Pierce discovered an



Jack Newton

Exploding Stars
Supernovae like 1994I in the Whirlpool Galaxy (arrow) help astronomers gauge distances to remote galaxies. However, the most predictable type of supernova, Type Ia, seems to yield distances that contradict those given by other methods.

error of about a third of a magnitude in the Baade-Zwicky calibration, which could explain at least part of the problem. Additionally, Mark Phillips of the Cerro Tololo Inter-American Observatory has discovered that not all Type Ia supernovae behave exactly the same. Phillips reports that some Type Ia supernovae decline in brightness more slowly than others. Those that decline slowly after peak brightness have slightly higher absolute magnitudes than the average Type Ia supernova, and those that decline quickly have slightly lower than average absolute magnitudes. Jacoby and Pierce found that 1937C was a slow decliner, meaning it was slightly brighter than the average Type Ia supernova. Correcting for this adds another 1/3-magnitude discrepancy. Taken together, the two errors suggest a Hubble constant that agrees with the other major methods.

"The bottom line is that four of the methods — planetary nebulae, RR Lyrae stars, Cepheids, and spiral galaxies — all agree extremely well with each other," says Jacoby. "Type Ia supernovae also agree in a relative sense — the problem comes in calibration."

The research by Jacoby and Pierce seems to add even more weight to the high-Hubble-constant side of the argument. This suggests the universe is relatively young and small — it may be that the universe is only 8 or 10 billion years old and stretches 8 or 10 billion light-years from edge to edge.

As the Hubble Space Telescope targets Cepheid variables in the Virgo Cluster galaxies, it's reasonable to ask whether decades of discrepancies and outright disputes over standard candles will come to an end in the next few years. Barry Madore and his collaborators are hoping to collect the data that will soon confirm the issue one way or the other.

But Madore cautions that the answer from Hubble will not be immediately clear. This is partly because the Virgo Cluster galaxies do not lie all at one distance from Earth. The cluster has a significant depth in the line of sight, so astronomers may have to survey many member galaxies before they can reach a consensus.

Mankind has lit many candles to light its way through the night. Astronomers are hoping they may soon find the brightest and most powerful one of all. □

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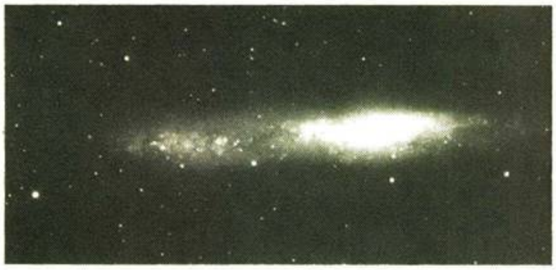

NGC 55 in Sculptor. 2 hour photo by Andrew Peters (from South Australia) using hypered 2415 film and a 20" f/5 telescope with LUMICON Coma Corrector and LUMICON 2" Easy-Guider. "The Coma Corrector is a terrific accessory," stated Mr. Peters. You may need to use a LUMICON Deep-Sky Filter to see NGC 55 visually.

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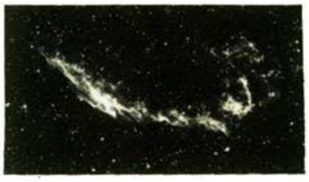

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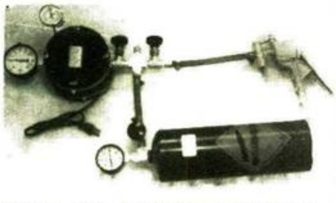

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MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$409,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$225,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

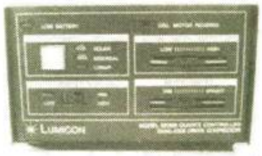
For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**



3. **LUMICON Digital Drive Corrector** . **$249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

Declination motor (state telescope) ... **$109**
Variable dec. speed drive w/built-in 5AH battery **$299**

HYPERSENSITIZED FILM

NEW
SRV3200

YES! WE STILL HAVE FUJI HG400!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	**24**	**$14.95**
Scotchrome 400, fast slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

NEW MEADE® 16" LX200 $14,950 AT LUMICON

"What an astounding combination of high performance and low price!" Jack Marling, Ph.D., owner of LUMICON

TOLL-FREE ORDER LINE 1-800-767-9576 EXPERT INFORMATION 1-510-447-9570 FAX 1-510-447-9589

MEADE APOCHROMAT ED REFRACTORS

7'' f/9
Apochromat
Only
$5495
7'' IN
STOCK!

Meade 6'' f/9 Model 152ED Refractor shown with #1697 Computer.

See the Meade ad in this magazine for full specifications and product descriptions. ED = Extremely low dispersion glass which yields color-free virtually perfect images. PPEC = Permanent Periodic Error Correction "Smart Drive."

Model 102 ED 4" f/9 Apochromat & mount (add $105 P&S)	**$2195**
Model 127 ED 5" f/9 Apochromat & mount (add $125 P&S)	**$2795**
Model 152 ED 6" f/9 Apochromat & mount (add $185 P&S)	**$4495**
Model 178 ED 7" f/9 Apochromat & mount (add $215 P&S)	**$5495**
Medium format adapters	Mamiya 645, **$98;** Pentax 6X7, **$98**
Med. format EASY-GUIDER™:	Mamiya 645, **$298;** Pentax 6X7, **$298**

DRIVE SYSTEMS

#1664 Electronic Drive with PPEC & 2X, 32X slewing system	**$375**
#1697 Computer Drive, 747 object computer memory, automatic slewing to desired object	**$695**
8,000 Object CNGC Library	**$99**
Polar alignment finder	**$99**

OPTICAL TUBE ASSEMBLIES (OTA)

Model 102 ED/OTA 4" f/9 OTA only (add $55 P&S)	**$1045**
Model 127 ED/APO-OTA 5" f/9 OTA only (add $60 P&S)	**$1595**
Model 152 ED/APO-OTA 6" f/9 OTA only (add $100 P&S)	**$2295**
Model 178 ED/APO-OTA 7" f/9 OTA only (add $120 P&S)	**$3250**
Cradle ring assem. 4" (4½" OD tube) **$135;** 5" (5½" OD tube)	**$145**
Cradle ring assem. 6" (7" OD tube) **$169;** 7" (8" OD tube)	**$219**

EQUATORIAL MOUNTS

LXD 600 mount and standard field tripod (add $60 P&S)	**$1350**
LXD 700 mount and giant field tripod (add $100 P&S)	**$2250**

NOTE: Add the indicated packing and shipping (P&S) costs to each telescope for insured UPS shipment to your door.

MEADE DOBSONIANS

Drop shipped from Meade, add shipping charge in parenthesis.

6" f/8 Starfinder Dobsonian ($39)	**$295**
8" f/6 Starfinder Dobsonian ($49)	**$395**
10" f/4.5 Starfinder Dobsonian ($69)	**$565**
12.5" f/4.8 Starfinder Dobsonian ($79)	**$765**
16" f/4.5 Starfinder Dobsonian ($45)	**$1195***

**Shipped truck freight collect; add $45 packing charge. Includes #682 focuser.*

NEW MEADE EYEPIECES

Series 3000 Plossl 1¼" eyepieces: select 5mm, 6.7mm, 9.5mm, 16mm, 25mm	**$59.95**
Select Any 3	**$48.95 ea.;**
Any 5	**$46.95 ea.**
Series 3000 40mm Plossl 1¼" eyepiece	**$79.95**

Shipping charges of 4-5% are extra.

NEW MEADE 16'' LX200 SCHMIDT-CASSEGRAIN

16'' LX200 $14,950
8'' LX200
$2295

NEW Meade 8'' LX200 Telescopes

See the Meade ad in this magazine for full specifications & details. **LX100 Drive**, 2X, 32X speed control with PPEC (Permanent Periodic Error Correction "Smart Drive") & dual-axis hand controller. **LX200 Drive**, Full electronic control with PPEC, 747 object computer memory and automatic computer controlled slewing to desired object. *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your Schmidt-Cassegrain.

8'' LX100 Schmidt-Cassegrain with wedge (add $105 P&S)	**$1995**
8'' LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2295**
Wedge for photographing with 8'' LX200	**$110**
10'' LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2895**
10'' LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2895**
NEW! 12'' LX200 (f/10 only) with computer (add $215 P&S)	**$3995**
Super Wedge for photography with 10'' or 12'' LX200	**$395**
NEW! 16'' LX200 f/10 w/super giant tripot (add $385 P&S)	**$14,950**
Library Option 1: 10,600 NGC, Messier, IC objects (Ver. 3.2 only)	**$99**
Library Option 2: 64,350 celestial objects (Version 3.2 only)	**$149**

OTHER SCHMIDT-CASSEGRAINS

Meade 2045D 4'' f/10 with motor drive (add $40 P&S)	**$699**
Meade 2080B 8'' f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
Model 2120B 10'' f/10 w/wedge, tripod, MCOG (add $125 P&S)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER 4'', 8'' only, f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10'' or 12'' f/4-f/10 operation	**$395**

MEADE STARFINDERS

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6'' to 16'' Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (=48X) eyepiece.

6'' f/8 **Starfinder 6**(add $65 P&S)	**$599**
8'' f/6 **Starfinder 8** (add $75 P&S)	**$699**
10'' f/4.5 **Starfinder 10** (add $90 P&S)	**$799**
16'' f/4.5 **Starfinder 16** (ship. freight COD)	**$2250**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $99 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

LUMICON Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$450**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livemore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector
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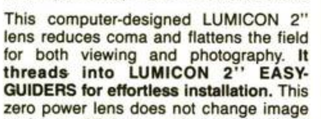
MODE
ENTER
UP
DOWN
LUMICON

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

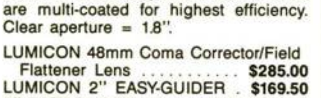
Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½'' f/4.5



Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$169.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6X7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$235.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$59.50**
LUMICON 2'' Helical Focuser 1½'' high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' adapter w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$179.50**
1¼'' right-angle 80mm SUPER-FINDER	**$189.50**
1¼'' right-angle version, w/star diagonal	**$229.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$49**
Large mounting rings for 80mm Finder	**$55**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$52.44**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$26.00**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

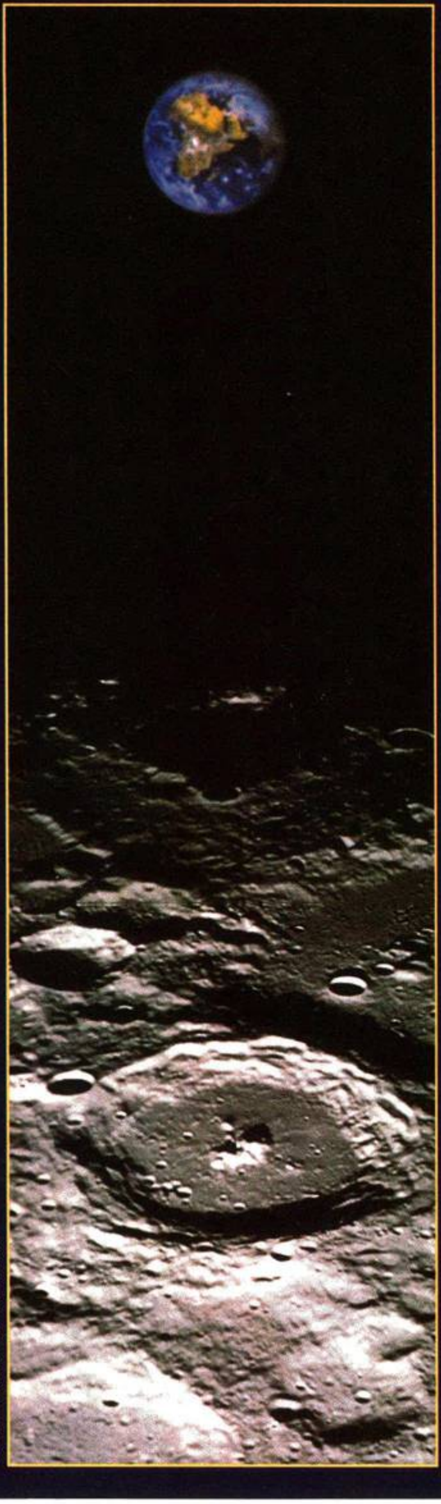
EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**16.00**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$26.00**
2'' long extension for 2'' eyepieces*	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$20.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

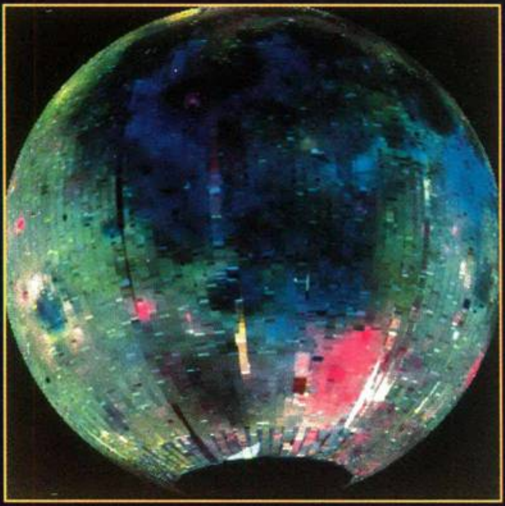
**Threaded to hold 48mm filters.*


Clementine Science Team/USGS

EARTH RISES over the Moon's north pole as Clementine completes a mapping orbit of the farside and prepares to transmit data to Earth. The large crater in the foreground is Plaskett.

NRL

THE SUN'S CORONA PEEKS OUT from behind the Moon's limb, with Saturn, Mars, and Mercury arrayed in order from the Sun. The faint illumination on the Moon comes from sunlight reflected by Earth.

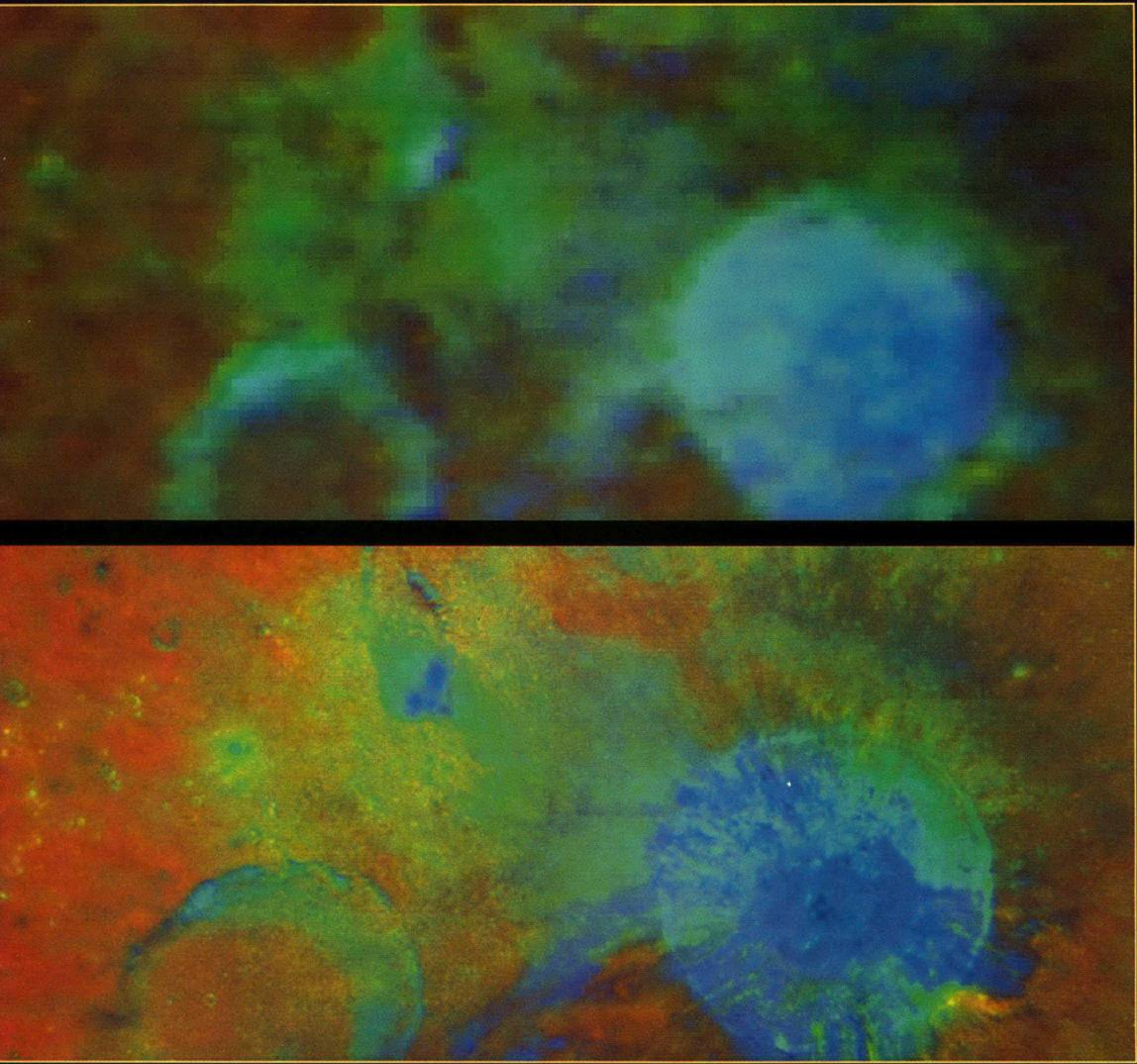

ACT Corporation

VIEWING THE MOON at many wavelengths helps scientists deduce the nature of the lunar surface. In this view from above Oceanus Procellarum, green denotes old highland terrain, red signifies fresh highland craters, and blue marks mare lavas.

THE MOON COMES INTO FOCUS

Early results from Clementine's battery of sophisticated instruments reveal a new and exciting Moon.

by Richard Talcott

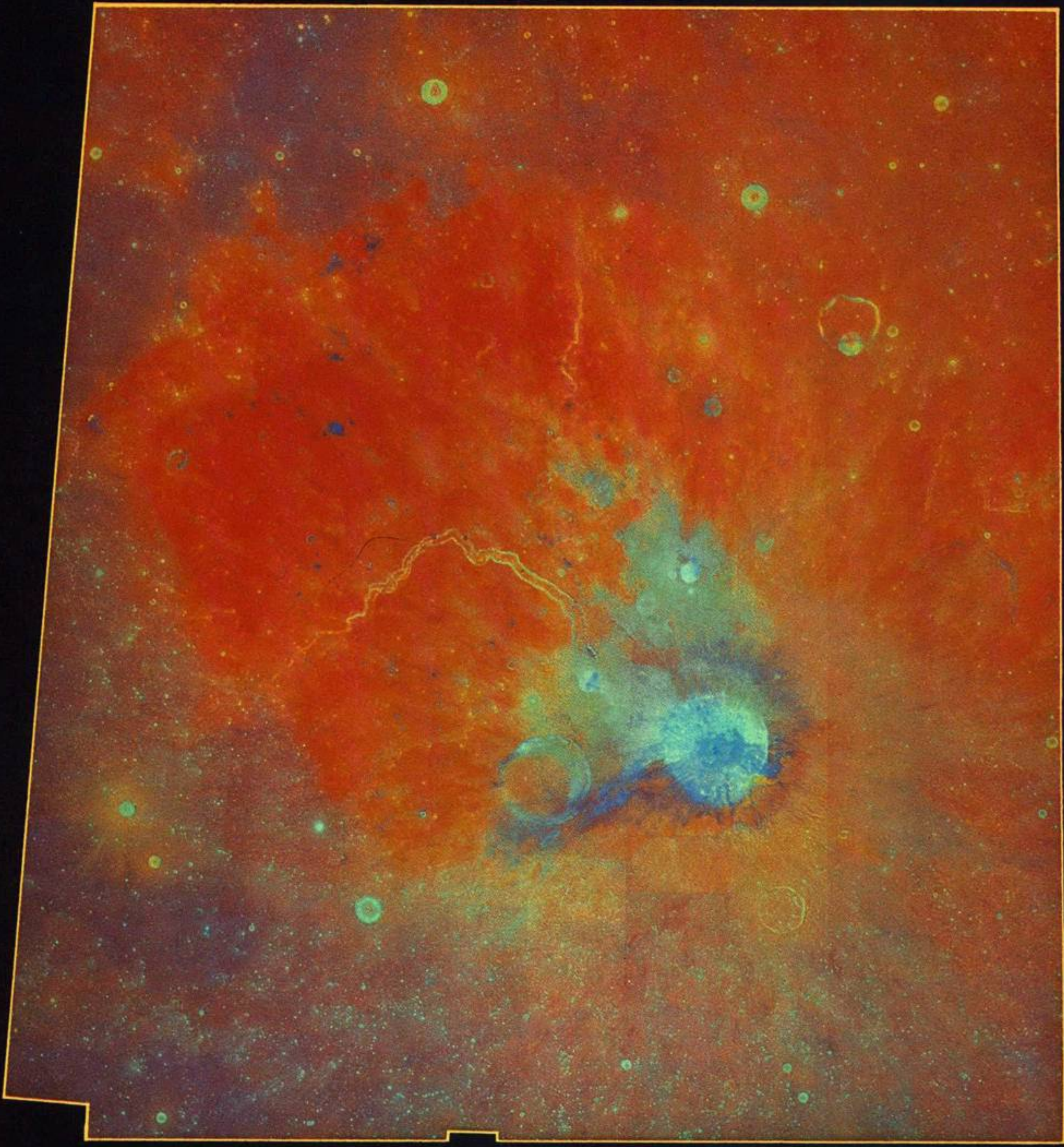


Clementine Science Team/USGS

HOW GOOD IS CLEMENTINE? Compare the Galileo spacecraft's multispectral image of Aristarchus (top), the best made of this crater before Clementine, with Clementine's highly detailed view (above).

Eighteen years after their last mission dedicated to studying the Moon, space scientists returned to our satellite earlier this year on the wings of America's Clementine spacecraft. Funded by the Department of Defense, Clementine spent two months orbiting the Moon and mapping its whole surface in unprecedented detail. Unfortunately, after breaking free of lunar gravity and while rehearsing for a planned close encounter with the asteroid Geographos, the spacecraft began tumbling uncontrollably, effectively ending the mission.

Despite its untimely end, the mission was a rousing success. During its 71 days in lunar orbit from February through April, Clementine systematically mapped all of the Moon's 38-million-square-kilometer surface, took tens of thousands of high-resolution images, and measured the Moon's topography and surface gravity. All of the spacecraft's sensors performed up to or beyond expectations.



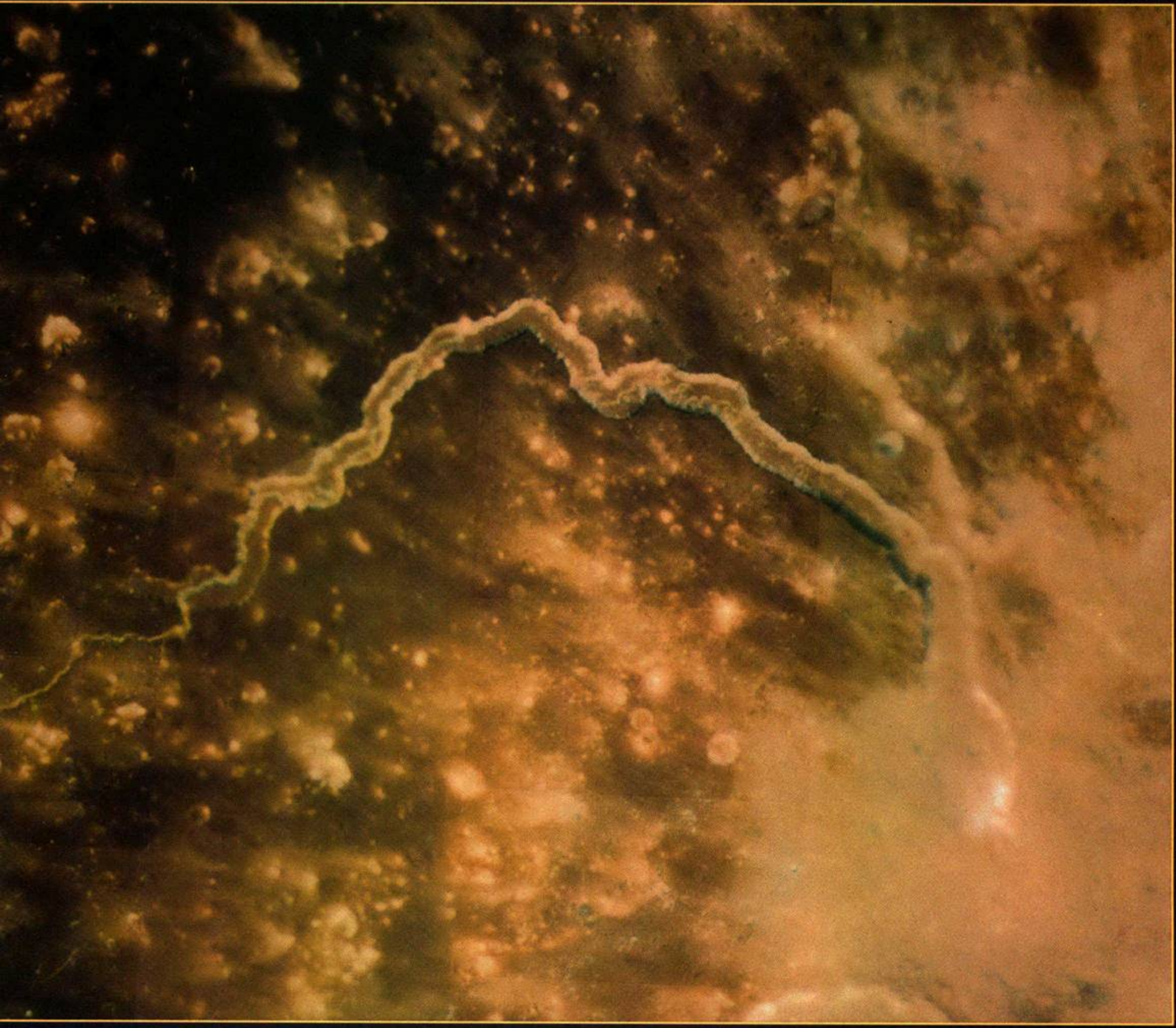
Both photos by the Clementine Science Team/USGS

VOLCANIC ACTIVITY HELPED SHAPE the vast Aristarchus plateau. In this image, highland material is blue, fresh mare material is yellow, and older mare material is purple or red.

Clementine's primary assignment was to map the entire surface of the Moon in great detail by taking images at 11 wavelengths in the visible and near-infrared parts of the spectrum. By combining images made at different wavelengths, planetary scientists can identify specific minerals and rock types on the lunar surface.

The global maps have an average resolution of about 200 meters, while the high-resolution camera can see details as small as 10 meters across. That compares with resolutions as good as 1 meter in images made in the 1960s of the Apollo landing sites. But surprisingly, prior to Clementine some areas of the Moon had not been mapped at all and others only at resolutions of several hundred meters. The polar regions, in particular, were poorly mapped because most previous spacecraft flew in equatorial orbits.

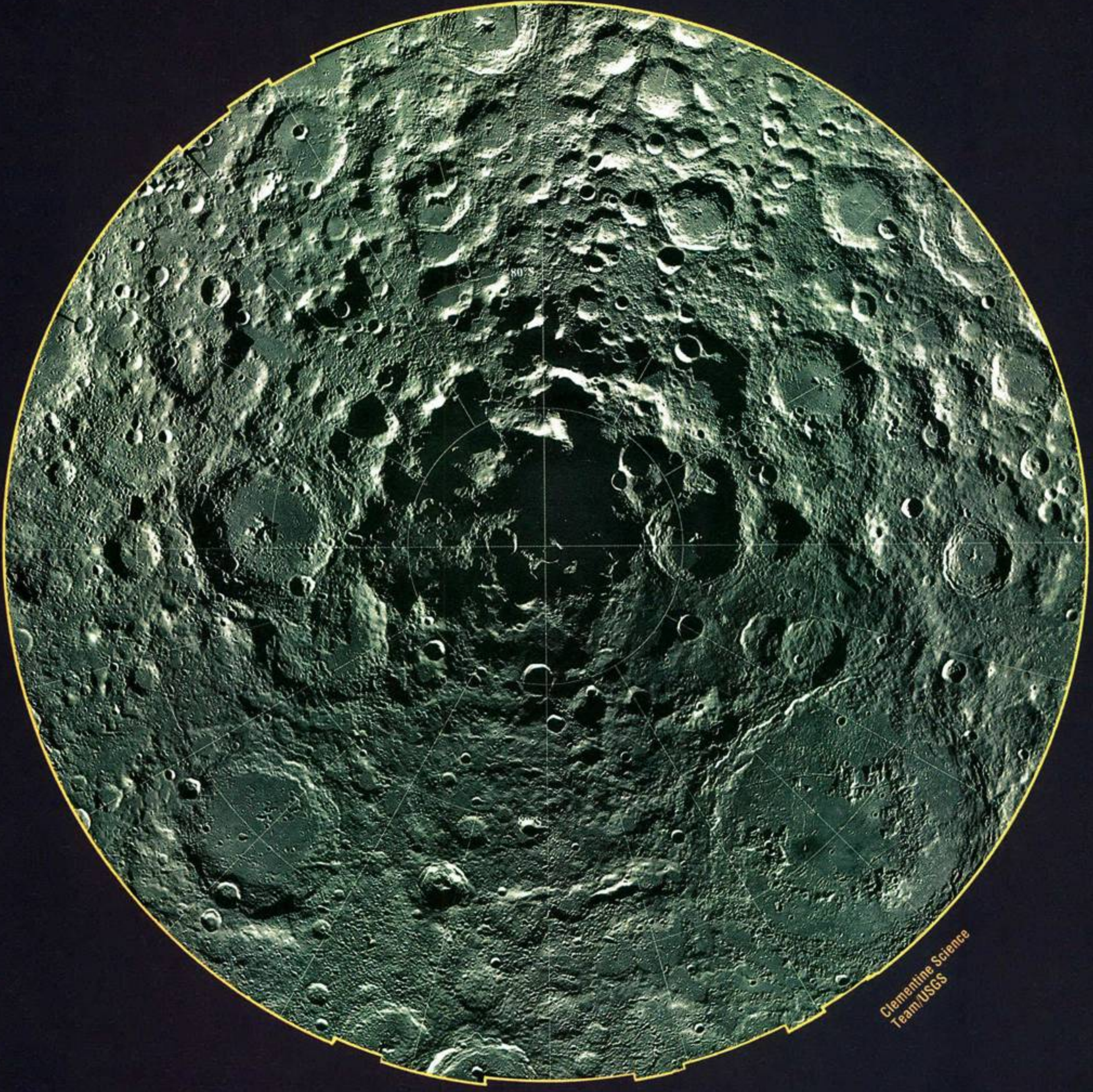
All that changed with Clementine. As soon as planetary scientists put together a mosaic of over 1,500 images of the Moon's previously unmapped south polar



THE LARGEST SINUOUS RILLE ON THE MOON, Schröter's Valley, lies on the Aristarchus plateau and extends for 160 km, measuring up to 11 km deep and 1 km wide.

region, they discovered an ancient impact basin some 300 km across (see page 44). The basin is the large, dark area just above and to the right of the pole. Because the Moon rotates on an axis that is nearly perpendicular to the plane of its orbit around the Sun, the interior of this basin may remain in perpetual shadow and at a frigid temperature of about –233° Celsius. Some scientists suggest that water molecules from impacting comets could find their way into this "cold trap" and accumulate over the course of billions of years (see "Search for the Lost Lunar Lakes," March 1993). Clementine beamed radio waves into the polar area looking for the signature of water ice. The results of that experiment are still being analyzed.

As of late spring, planetary scientists had taken a preliminary look at the global multispectral data, although to easily manipulate the immense amount of data they had to reduce the resolution by a factor of several hundred. And they had begun to study in more detail some geologically complex regions such as the



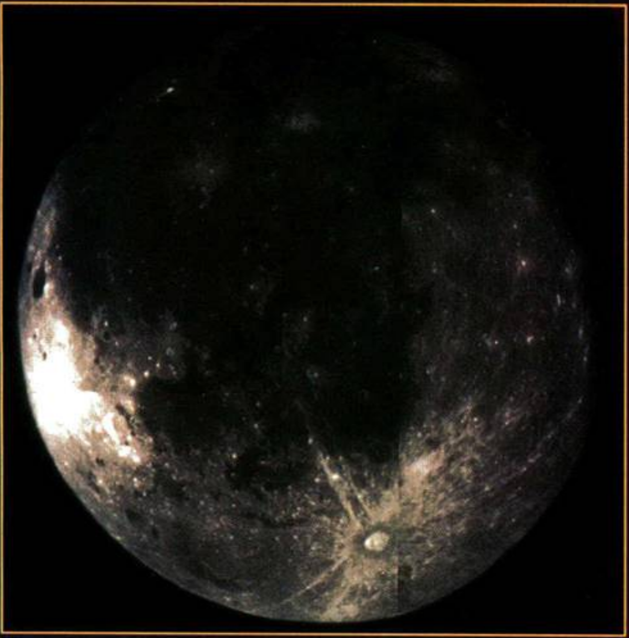
Clementine Science Team/USGS

CLEMENTINE MAPPED THE MOON'S SOUTH POLE for the first time, revealing a previously unknown basin that may be forever in shadow. By analyzing the craters in Schrödinger, the large basin at 4 o'clock, scientists used the Clementine images to show it is the Moon's second youngest impact basin.

Aristarchus plateau (pages 42-43), which shows the scars of mighty impacts as well as evidence of volcanism.

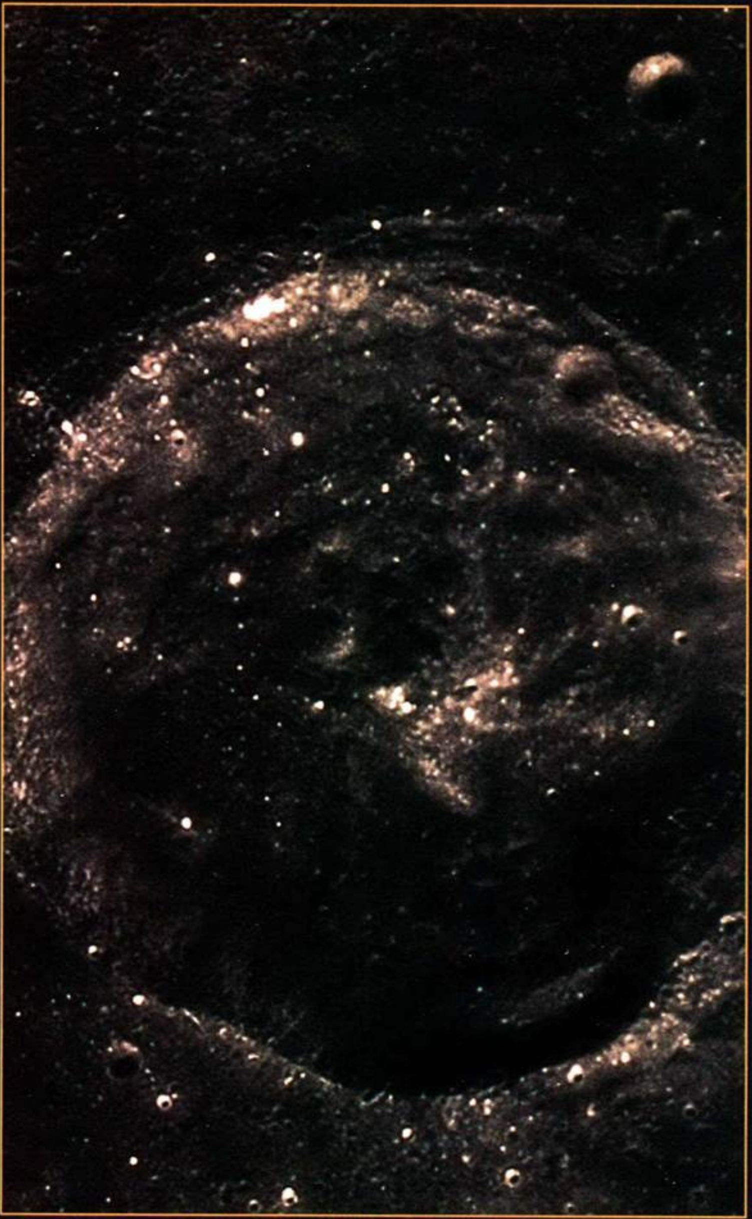
Clementine's laser-ranging experiment proved as valuable as the spacecraft's battery of cameras. It showed for the first time the extent of the largest confirmed basin on the Moon, the South Pole-Aitken basin. With a diameter of 2,500 km and a depth averaging 12 km, this is the largest impact feature known in the solar system. The laser-ranging experiment also confirmed the presence of several very old, nearly obliterated impact basins that range from 5 to 7 km deep. Using radio signals to track the spacecraft and thereby probe the Moon's gravity, Clementine showed that dense material from the lunar mantle has been uplifted beneath these basins.

The original goal of the Ballistic Missile Defense Organization, the agency in the Department of Defense that ran the Clementine program to space-qualify



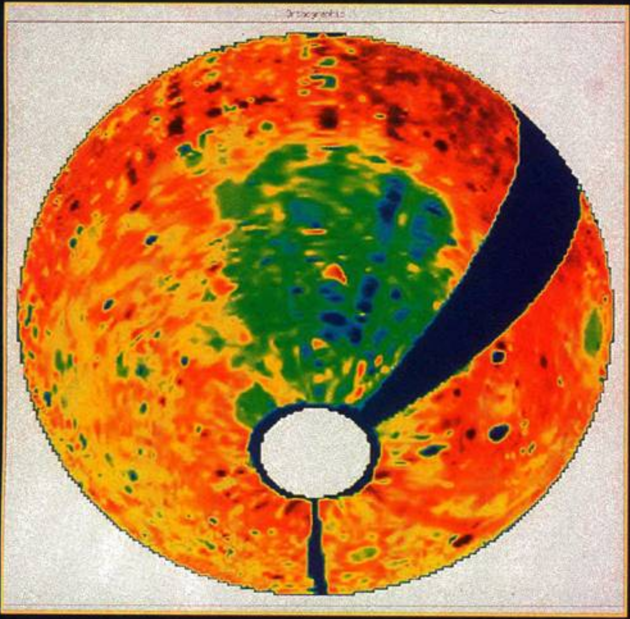
NRL

EARTHSHINE LIGHTS THE MOON in this mosaic taken from 2,600 km up. The bright rayed crater Tycho lies at bottom while Aristarchus is the bright point at upper left.



NRL

RYDBERG CRATER DOMINATES this region of the Moon's farside. The 50-km-wide crater lies a few dozen km south of ridges created by ejecta from the Mare Orientale impact.



LPI

A HUGE IMPACT CREATED the South Pole-Aitken basin, the largest known in the solar system. It's the green area at center in this image made from Clementine's laser-ranging data.

lightweight imaging sensors and components, was to make the Moon just the first stop on a longer mission to explore the inner solar system. After the Moon mission, Clementine was scheduled to fly past the asteroid 1620 Geographos in late August, giving scientists their first-ever closeup look at a near-Earth asteroid.

After leaving lunar orbit in early May, Clementine returned to Earth orbit in preparation for its journey to Geographos. But during a rehearsal for the August asteroid encounter, the spacecraft began to tumble and mission controllers lost contact for a while. During this time the reaction-control jets fired, using up almost all of the attitude-control fuel. Contact was soon re-established but, as of mid-June, the spacecraft remained spinning and mission controllers weren't sure they would be able to stop it. Although all systems are working fine, the lack of attitude-control fuel scuttles any chance for a Geographos encounter. So from a scientific standpoint, Clementine now appears to be lost and gone forever. ☐

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If you are not completely satisfied with your purchase from Orion, for any reason.
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Just return it in new condition within 30 days after delivery for a prompt refund.

Celestron Ultima 2000 —

The new leader in computer driven Schmidt-Cassegrain telescopes, at Orion now!

Orion is the place to call for the best price and fastest delivery on Celestron's hottest new telescope! At last, a SC telescope that moves quickly and quietly from subject to subject. Much faster, much lighter weight, much easier to use than any other telescope! Revolutionary new mount with roller drive...NO worm gear periodic error! Fantastic easy-to-use controller with huge 10,000 subject database. Completely powered by penlight batteries! Complete information in our new catalog!

$CALL for our low, low price!

DEEP SPACE EXPLORER™

#9901 **$299** (39.00) 6" f/8	#9902 **$399** (49.00) 8" f/6
#9903 **$599** (69.00) 10" f/5.6	#9904 **$769** (79.00) 12.5" f/4

Prices include precision helical focuser and 25mm Sirius Plossl eyepiece!

The best telescope choice in the universe for beginning amateur astronomers!

Featured in an in-depth article in *Astronomy* magazine (12/93) and in the *Sky & Telescope* article "Choosing a Low-Cost Telescope" (12/93). *(Ask for free reprints.)* Find out what the reviewers have been raving about: the Orion Deep Space Explorer telescopes offer the highest-performing complete optical system available!

Ideal for both beginners and advanced astronomers, these great new scopes offer high performance and lasting value. With their fantastic precision ground and polished reflector optical systems, they are ideal for interplanetary, lunar, and deep space observation.

Compare the features to any other telescope: superb hand-figured optics that out-perform similar sized and even larger-sized competitive scopes; a first-rate fully coated Sirius Plössl eyepiece; a quality machined aluminum low-profile helical focuser; low diffraction stay-put secondary support, providing 4 times less diffraction than four-vane "spiders" on competitive models; unique counterbalance mounting point; acclaimed smooth-motion Dobsonian mount.

Binoculars for Astronomy

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Rubber Armored Model #9627 **$159** (5.07)
Standard Model #9504 **$159** (4.71)

50mm Explorer™ Binoculars

High performance large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design. Include case and straps

7x50 #9306 **$117** (4.44)
10x50 #9308 **$127** (4.44)

Orion 50mm UltraView™

The perfect binocular for eye and sunglass wearers. Extra-long 23mm eye relief and unique rubber pop-down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics provide high light transmission and maximum contrast compared to standard coated types. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz. Includes case and straps.

10x50 #9351 **$159** (4.95)
NEW! 7X50 #9357 **$159** (4.95)

Orion 50mm Vista™

Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghosting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

10x50 5.3° field of view #9353 **$219** (5.19)
NEW! 7X50 6.0° field of view #9355 **$219** (5.19)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501 **$319** (6.97)
14X70 #9494 **$319** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 **$439** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 **$439** (8.05)

20x80 MC-Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 **$439** (8.05)

Orion Standard Series 80mm Giant Binoculars

Made in the same factory as name brand models selling for much more! Fully coated optics with multi-coatings and BAK-4 prisms. Smooth center focus design. Soft rubber fold-back eyecups. Include lens caps, straps, and carrying case.

11x80 model Bright 7.1mm exit pupil, 4.2° field of view #9480 **$349** (7.76)

16x80 model 5mm exit pupil, 3.5° field of view. #9482 **$349** (7.76)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

Sale!
14x100 #9495 **$799** (29.00)
25x100 #9497 **$799** (29.00)
Shipped by FedEx only.

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case (shown) 11"x7"x3" #5951 **$17.95** (2.78)
Medium Case 12.5"x9"x5" #5952 **$26.95** (3.36)
Large Case 16"x11"x5" #5953 **$49.95** (5.19)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.
8" Celestron/Meade SC #4200 **$44.95** (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers—fit all Meade & Celestron 8" SCs DC #3503, AC #3504 **$47.95** (2.98)
10" Dew Zappers—fit all Meade 10" SCs DC #3506, AC #3508 **$54.95** (2.98)
11" Dew Zappers—fit all Celestron 11" SCs DC #3510, AC #3512 **$59.95** (2.98)

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8" Model #15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11" #15131 **$39.95** (2.43)

Now available for Deep Space Explorers! Ask about other sizes.

Observer's Chairs

Standard Model—Adjustable height center column and padded seat. #5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty. #5934 **$89.95** (8.02)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Nitewriter Pen	#5709	**$8.95** (1.79)
Hands-Free Flex Light	#5707	**$17.95** (2.43)
Starlite LED Flashlight	#5714	**$24.95** (2.43)
Celestron LED Flashlight	#5720	**$21.95** (2.43)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

NEW! *Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$14.95** (2.43)

Color Eyepiece Filters

Made from absolutely the highest quality photographic-grade precision-ground optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. The black anodized, machined aluminum cells thread into any standard eyepieces, or into our universal camera adapters.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 **$46.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$48.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets. #5517 **$84.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set. #5575 **$124 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow. #5513 **$89.95 set** (2.98)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

The finest available, SkyGlow™ filters from Orion make detailed deep-sky observing possible from light polluted city and suburban locations. Sophisticate multi-layer technology actually absorbs light pollution! Greater blocking and higher transmission than competitive models. See catalog for details..

SkyGlow UltraBlock Filters– Visual Only

For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces. #5654 **$97.50** (3.45)
2" UltraBlock Filter–fits 2" eyepieces. #5657 **$119** (3.67)
.965" UltraBlock Filter–fits .965" eyepieces. #5655 **$77.50** (3.67)
SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes. #5656 **$129** (3.67)

SkyGlow Broadband Filters—Photographic and Visual

For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces. #5660 **$69.95** (3.45)
SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes. #5658 **$89.95** (3.45)
52mm Broadband Filter–For 52mm camera lenses. (Adapter rings available for other diameters.) #5668 **$87.50** (3.45)
2" Broadband Filter–fits 2" eyepieces. #5659 **$109** (3.45)
.965" Broadband Filter–fits .965" eyepieces. #5661 **$49.95** (2.98)

Accessories

Call Toll-Free For Our Huge 100 Page Catalog and See Even More!
Orion Accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

Universal Camera Adapters
For prime focus or eyepiece projection astrophotography.
.965" #5268 **$26.95** (2.98)
1.25" #5264 **$28.50** (2.98)
Hybrid 1.25"/.965" #8782 **$28.50** (2.98)

Variable Power Camera Adapter
Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.
#5262 **$38.50** (2.98)

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.
#7012 **$59.95** (2.98)

Extension Cable for Slow Motion Control
12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.
#5014 **$17.95 ea.** (2.43)

Tele-Extenders for SC Scopes
For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.
Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters for SC and MAK
Threads to rear cell of telescope, requires t-ring for your camera model.
for SC #5116 **$26.50** (2.98)
for C-90 #7115 **$29.95** (2.98)

T-Rings for all 35mm Cameras
Available for many different camera types, call toll-free or see our catalog for your particular model.

45° Erect Image Diagonal Prisms
See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.
1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792
$44.95 (3.45)

90° Star Diagonal Prisms
Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.
1.25" Star Diagonal #8763 **$48.95** (2.98)
.965" Star Diagonal #8761 **$29.95** (2.98)
Hybrid 1.25"/.965" Star Diagonal #14008 **$31.50** (2.98)

Orion Ultra™ 2" Diagonals
Your SC or refractor deserves the finest. Both models are the finest optical quality and use the best coatings available.
2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.
For refractors #8770
For Schmidt-Cass. #8771 **$199** (4.71)
2" Mirror Diagonal– Affordable, high-quality first-surface optical flat star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95** (3.45)

Revision of our Summer Catalog Comparison of Celestron Ultima 2000 and Meade LX200

Our Summer Catalog #942, page 5, mistakenly listed the slew rate of the LX200 as 6° per second. The correct figure is 8° per second. (The Celestron figure of 10° per second is correct.) The text also incorrectly reported how the Dec. and R.A. locks work on the LX200. Both clamps are locked in normal operation. The point we were attempting to convey was that since the Ultima 2000 has NO locks, it is simpler and has less possibility of confusion in its operation. Please contact us if you would like a fully corrected product comparison. We apologize to Meade Instruments and to our customers for not discovering these errors prior to printing.

Orion Off-Axis Guider
Allows you to observe a guide star during photography. Multi-coated.
#5144 **$69.50** (3.45)

Orion UltraGuider
Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.
#5139 **$119** (4.19)

110v Motor Drive for Refractors
Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.
#17001 **$72.50** (3.95)

12 Amp Hour Porta Pac Battery
Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.
#2354 **$109** (8.97)

Eyepieces

2
3b
3c
3a
5
1
See Our Huge 100 Page Catalog for Many More! Including a Fantastic Selection of Name Brand Eyepieces!
New!
40mm
✧Sirius™
Plössl

1 ✧ *Sirius*™ *Plössl 1.25" Eyepieces*
Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!
You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!
Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard by which all other eyepieces are compared.

The Fully Magnesium fluoride coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.
25mm #8530, *17mm* #8531, *10mm* #8532, *7.5mm* #8533 **$57.95 ea.** (3.45)
New! *40mm* #8529 **$79.95** (3.67)
Case only #5911 **$12.95** (2.19)

SPECIAL OFFER–Buy Two or More and Save!
- *Any 2 .... $10 off (Save $5 ea.)*
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- *Any 4 .... $60 off (Save $15 ea.)*
- *ALL 5 .... $85 off (Save $17 ea.)*

Bonus—Free case with purchase of 2 or more!

Buy Two Get One FREE!
Limited Time Special Offer!

Buy any two Ultrascopic eyepieces and get your choice of a 10mm or 7.5mm free! *Limited offer subject to stock availability.*

2 Orion 5-Element Ultrascopic™ Eyepieces
With superb Ultra™ Multi-Coatings!
Made for Orion by Japan's finest lens maker, Ultrascopic eyepieces yield the highest contrast, greatest light transmission, and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on *every* surface, they achieve a level of performance "name brand" 4-element models can't match. Wide 52° flat field of view. Removeable coutoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs which yield surprisingly long eye relief. Absolutely guaranteed to knock your socks off!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$89.95 ea.** (3.45)
Wide Field 5-element
25mm #8564 **$99.95** (3.45)
30mm #8562, **35mm** #8560 **$109 ea.** (3.45)
***High Power 7-element** —Long Eye Relief*
5mm #8574, **3.8mm** #8576 **$89.95** (3.45)

3 Orion Explorer™ Multi-Coated 1.25" & .965" Eyepieces
These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

b *1.25" Orthoscopic*
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$54.95 each (2.98)

c *1.25" Kellner*
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$39.95 each (2.98)

a *.965 Orthoscopic*
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

a *.965 Kellner & Achromatic Huygenien*
K 18mm #8584, **K 25mm** #8585, **AH 40mm** #8586
$37.50 each (2.98)

Illuminated Reticle Eyepieces
A necessity for long exposure astrophotography and very useful for polar alignment.

12.5mm Plössl Illuminated Reticle 1.25"
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$109** (3.45)

9mm Orthoscopic Illuminated Reticle 1.25"
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$119** (3.67))

12mm Kellner Illuminated Reticle 1.25"
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$74.95** (3.45)

12mm Kellner Illuminated Reticle 1.25"
Same as 8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.
#8481 **$94.95** (3.45)

SR-44 Batteries (pkg. of 2) #2360 **$5.95** (1.79)

5 UltraZoom™ 7–21mm
The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.
#8556 **$169** (3.67)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$34.95** (2.98)
1.25" #8746 **$44.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$64.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$57.95** (3.45)

Shorty Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.
.965" #8710 **$39.95** (2.98)
1.25" #8711 **$49.95** (3.45)

Quality Components for Building or Upgrading

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with standard or 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.
See catalog for pricing.

6x30 Achromatic Finder Scopes
6x30mm—Same unit used on $1000+ "big name" telescopes. With 2-ring metal bracket, fits scopes 6"-12".
#13023 (white) **$49.95** (3.41)

6x30mm Right Angle—90° prism for right-angle viewing. Includes bracket.
#13021 (white) **$64.95** (3.41)

Large Aperture Finder Scopes
These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separatly.)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) **$64.95** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) **$89.95** (3.41)

9x60mm — 44% more light grasp than 50mm models.
#7091 (white) #7095 (black) **$89.95** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) **$129** (3.41)

Superb Dovetail Aluminum Mounts for 50mm and 60mm Finder Scopes
Instantly install or remove your finder, without tools, without disturbing alignment! Black anodized, Fits any scope 6" and over including Celestron & Meade SCs. *(pictured above)*
8x50mm bracket #5040 **$34.50** (2.45)
9x60mm bracket #5041 **$39.50** (2.98)

Low-Profile Helical Focusers
Economical yet precise focusing. Ideal for fast optical systems. Cast aluminum base with threaded machined aluminum inner tube.
1.25" #13014 **$39.50** (2.45)
2.0" #13016 **$59.50** (2.98)

Rack-and-Pinion Focusers

Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.
1.25" #13007 **$49.95** (2.98)
2.0" includes 1.25" adapter.
#13003 **$89.95** (3.95)

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Just return it in new condition within 30 days after delivery for a prompt refund.
GUARANTEE

IT'S EASY TO ORDER!
- Call toll-free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in parentheses after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for August 1994 at the time of our advertising deadline in June. Some price changes are expected September 1st. Please call our toll-free number for current pricing and to receive our latest catalog. Prices are subject to change or correction without notice.

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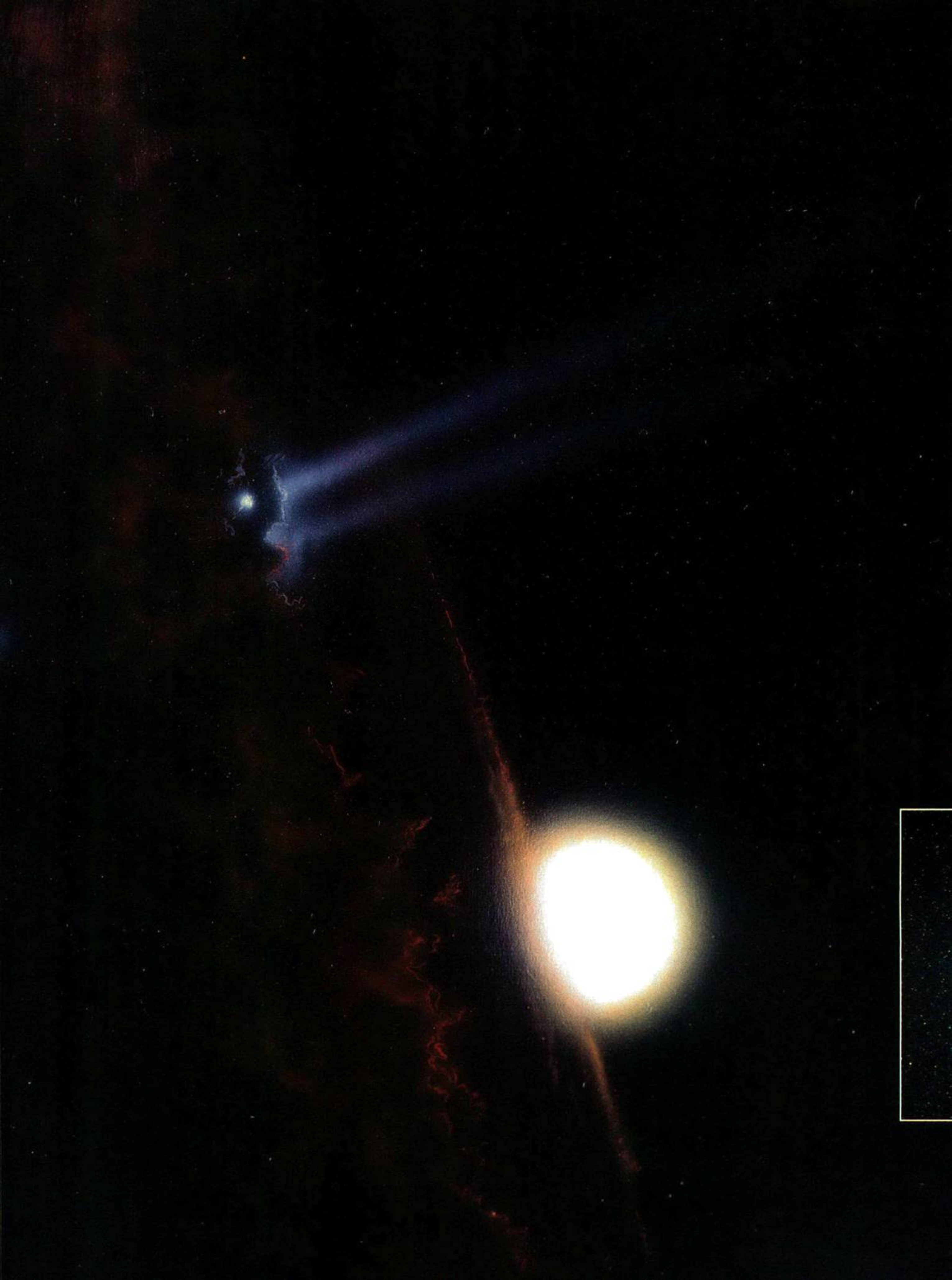


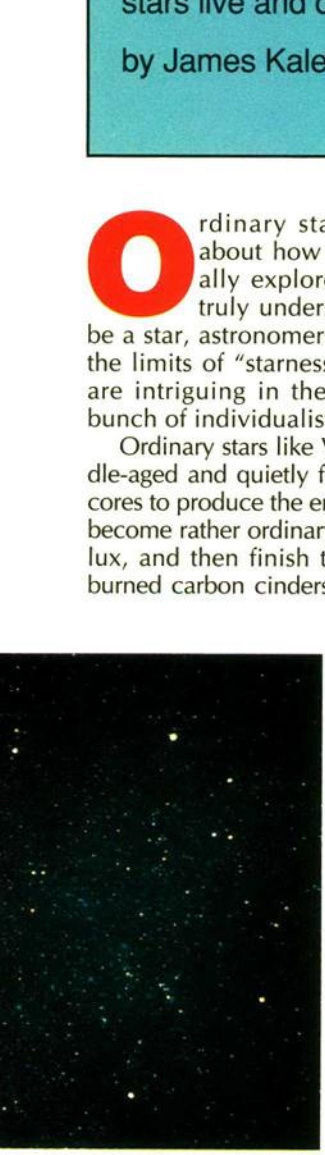
Stellar Oddballs

The true stellar celebrities aren't ordinary stars like the Sun. It's the strange ones that let astronomers peek at how stars live and die.

by James Kaler

Ordinary stars produce ordinary theories about how they form, live, and die. To really explore the limits of the theories and truly understand the secrets of what it is to be a star, astronomers have to look at stars that are at the limits of "starness." At the same time, these stars are intriguing in their own right because they're a bunch of individualistic oddballs.

Ordinary stars like Vega and Mizar are young to middle-aged and quietly fuse hydrogen into helium in their cores to produce the energy they radiate into space. They become rather ordinary giants, such as Arcturus and Pollux, and then finish their life cycles as white dwarfs, burned carbon cinders that are little more than the size of Earth. Even the rare supergiants, such as Antares and Betelgeuse, take part in the ordinary path of stellar life. These massive stars may finish their lives as supernovae, exploding in a final burst of light visible across millions of light-years. But even supernovae are not peculiar when compared to the oddballs.



Kenneth Paul Fye

A DYING DOUBLE STAR may churn the gas and dust in the disk that orbits the supergiant called Epsilon Aurigae, the star just below and to the right of bright Capella seen at top in the photo above.

Ron Miller

Oddball stars lurk among the ordinary ones. Take, for example, the stars in the constellation Auriga. The brightest star, Capella (the "She-goat"), is a rather ordinary pair of giant stars. But there's a neighboring eclipsing binary that ranks among the oddest stars known.

Epsilon Aurigae consists of a brighter, or primary, star, a whitish supergiant that, if placed at the Sun's position, would more than fill the orbit of Mars. What makes Epsilon an oddball is its fainter, or secondary, star. Usually in eclipsing binaries, a deep eclipse occurs when the larger of the two stars passes in front of the smaller but brighter star. In Epsilon's case, the eclipse happens every 27 years when an unseen companion blocks part of the supergiant's light for two years. The companion must be larger than the supergiant, but astronomers detect no starlight from this object.

Astronomers do see a faint infrared glow from a body that has a temperature of about 500 kelvins. They believe this glow comes from a huge disk of dusty gas the size of Saturn's orbit that circles the supergiant. From the motion of the supergiant as the two bodies orbit each other, observers have learned that the mass of the companion is far larger than a cloud of orbiting dust and gas could have.

Theorists have proposed two ideas to explain this puzzle. The first suggests that a star lies hidden in the disk. The disk contains the remnant gas and dust left behind when the companion formed. This protoplanetary disk is like the one our planetary system formed from and those seen around Vega and Beta Pictoris.

In the second idea, a pair of bluish-white main sequence stars orbits the supergiant. Some of the material in the wind that blows from the surface of the dying supergiant condenses into dust and collects into a disk around the pair of stars. A single star would slowly suck up the gas and dust in the disk but two stars orbiting each other keep the disk material stirred up.

So the dust in one case indicates star birth and in the other star death. Observers must patiently wait for the next eclipse to gather enough data so they can choose between these models. Unfortunately the next eclipse won't take place until 2009. When it does, astronomers will perhaps catch a better glimpse at the birth of stars and planets or at the death of a star.

As ordinary stars such as the Sun die, they shed a cloud of gas. The similarity of these clouds to a planet's disk when seen through small telescopes led William Herschel two centuries ago to call them planetary nebulae. Astronomers first thought that a star gently puffed off its atmosphere, making a spherical nebula (see "Ashes to Ashes and Dust to Dust," May 1994).

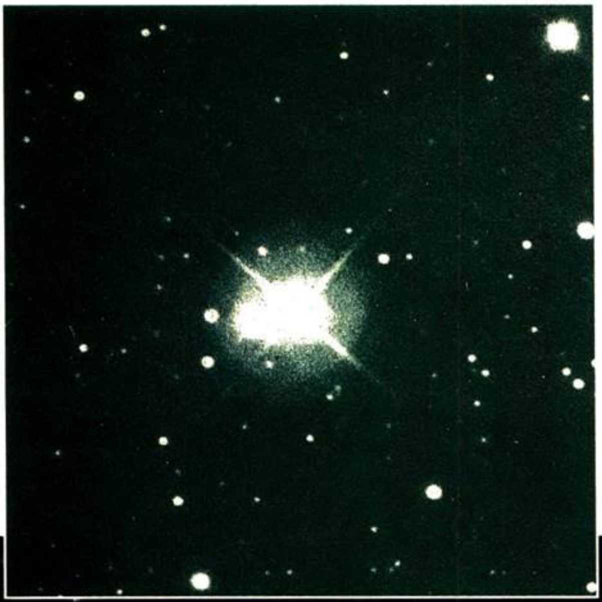
Now we know that a star forms a planetary by a two-step process. When the star was a giant, it lost a great deal of mass through a series of slow, dense winds. Once the outer hydrogen envelope was blown away, what remained was little more than the old nuclear-burning core that produced the star's energy. A fast wind then blew from the star and shoveled in front of it the gas lost in previous eons, much as snow is pushed by a snowplow on a city street. The planetary we see is the shoveled pile. Surrounding it, we can often see older surrounding shells. The fascinating shapes of different planetaries come from variations in how the wind blew from the giant.

But a few oddballs stick out here, too, challenging theories of how stars form planetary nebulae. Two cases are Abell 30 and Abell 78 (so named for their numbers in a catalog of planetaries produced by George Abell). Their central stars have knots of almost pure helium around them. These stars have already produced planetary nebulae once before, blowing off outer layers of hydrogen into space. After producing the nebulae, the stars started to contract to become white dwarfs. But as they contracted, helium surrounding the cores ignited in a flash. The rapid release of energy expanded the stars to giant size and blew the helium-rich outer layers into space forming the puzzling nebulae. Now the stars in Abell 30 and 78 are trying once again to form white dwarfs.

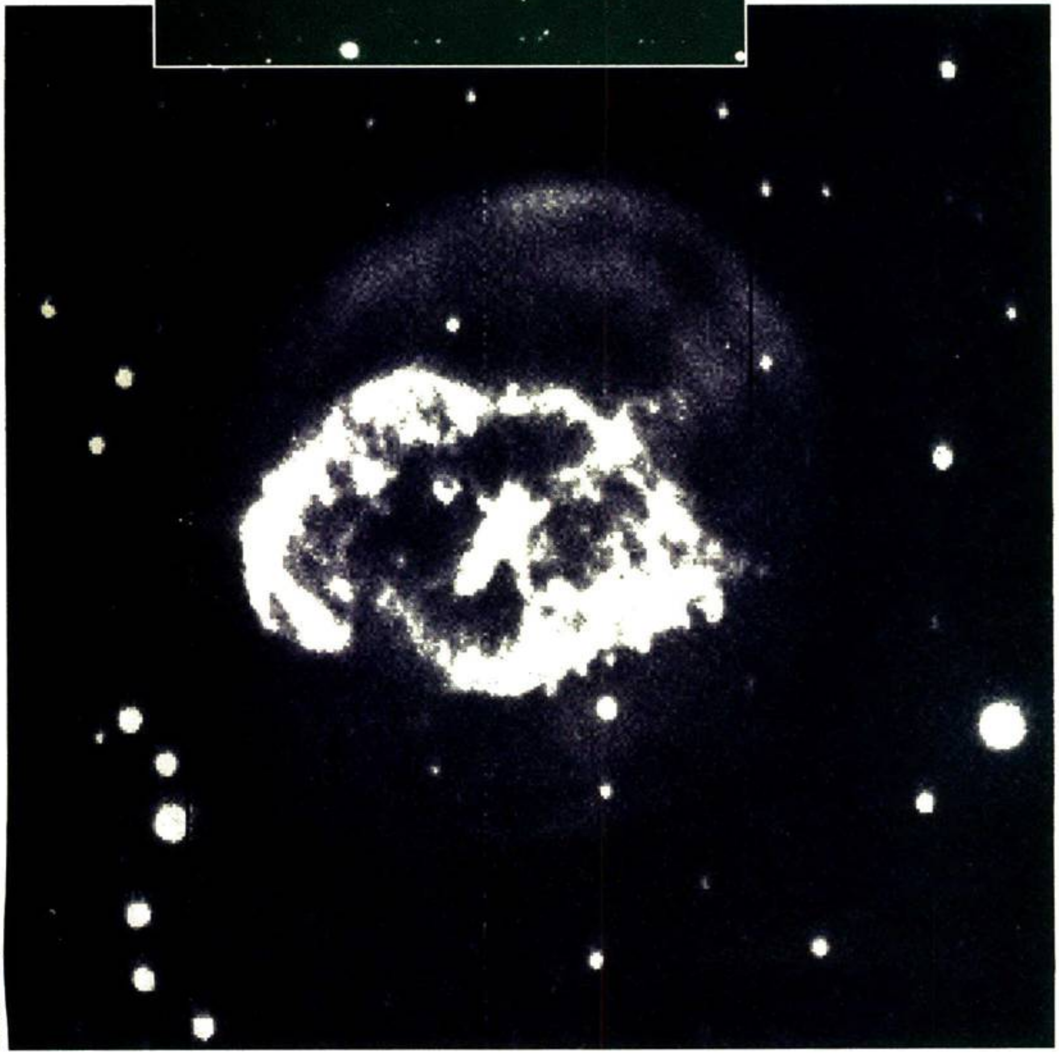
Stranger than these nebulae is a planetary in Sagitta named for the star at its center, FG Sagittae. Observers first recorded the star in 1894, when it had a magnitude of 13.6. Over the next 70 years the star brightened steadily and by 1965 reached magnitude 9.6. About that time, spectra revealed that the star was a whitish supergiant with a temperature around 10,000 K. Subsequently the star cooled, by roughly 250 K per year until 1983 when it reached a temperature of 5700 K (about that of the Sun), making it a yellowish color. Since then, FG Sagittae has heated up again to about 6500 K.

Peculiar changes in the spectrum of FG Sagittae accompanied the temperature changes. Ordinary stars exhibit numerous dark lines in their spectra caused by light metals such as iron, chromium, and titanium in their atmospheres. But FG Sagittae showed spectral lines belonging to barium and the rare-earth elements called lanthanides, including lanthanum and cerium. Ordinarily these lines appear faintly, if at all, in stellar spectra. In FG Sagittae, however, these unusual spectral lines are not just present, they dominate the star's spectrum. The lines of the light metals common in ordinary stellar spectra have nearly faded away in FG Sagittae.

Scientists call the odd atoms in FG Sagittae s-



George Herbig and Alexander Boyarchuk



George Jacoby, NOAO

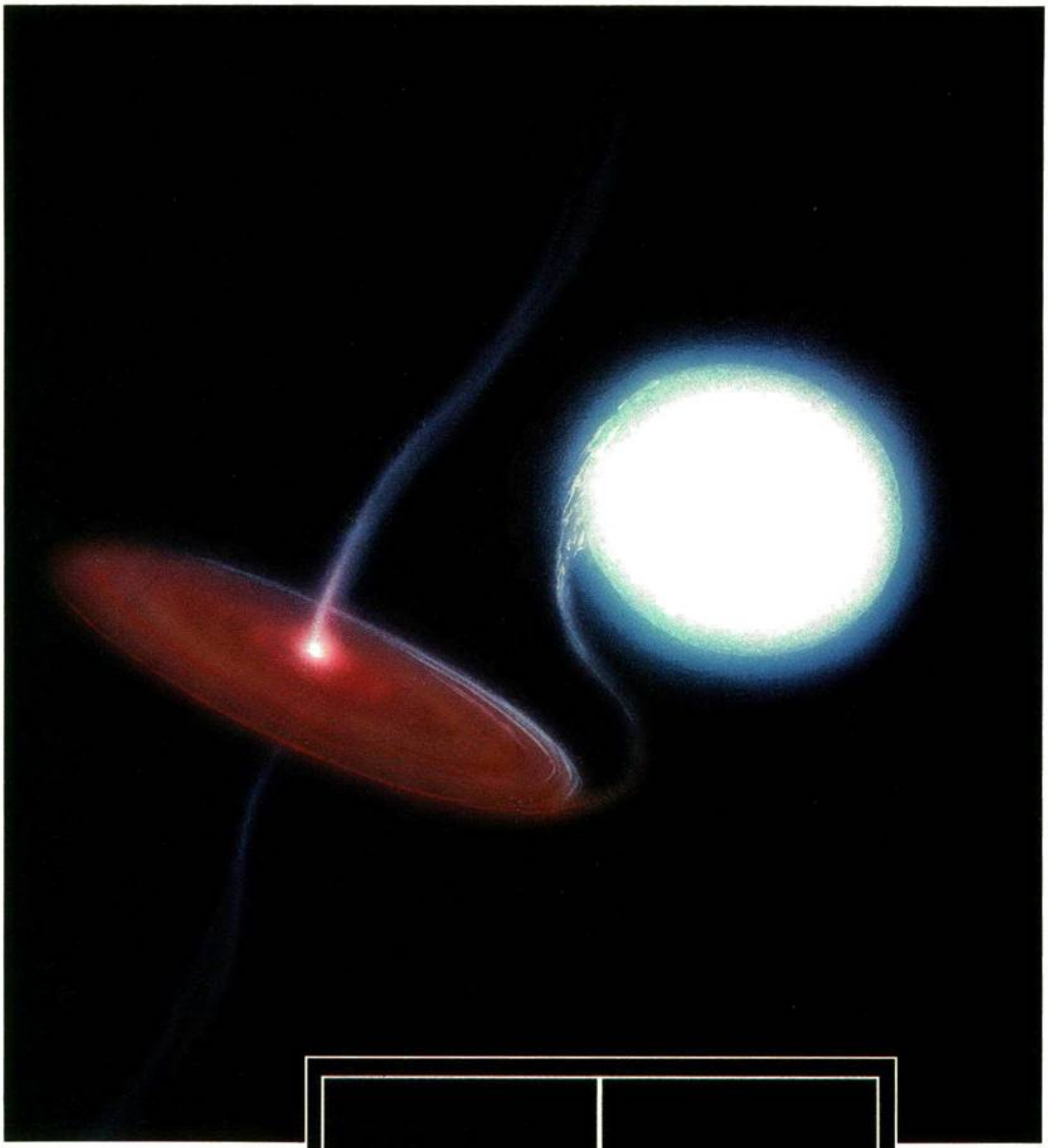
DISCARDING ITS OUTER LAYERS, FG Sagittae (top) may be producing an unusual second planetary nebula, just as the star in Abell 78 has done (left).

process elements because they are created by the *slow* capture of neutrons by the nuclei of atoms. For example, lanthanum can form when a barium nucleus, which ordinarily has 56 protons and 82 neutrons, captures another neutron. One of the 83 neutrons decays into a proton converting the atom into lanthanum, with 57 protons and 82 neutrons. Stars create s-process elements deep within their nuclear-burning hearts, and gas motions carry the newly formed elements to the surface. But only a star in the last stages of its life forms s-process elements, so FG Sagittae must be a dying star that threw off the gas that surrounds it in one of its death throes. The nebula apparently is still glowing from an earlier time when the now cool star was hot enough to excite the gas.

As the central star of a planetary nebula, FG Sagittae should appear hotter than it does. It's spectrum reveals that the star is blowing off mass. The temperature and color changes seem to indicate that a cool layer of expanding gas overlies the star within. FG Sagittae's mass loss may be producing another planetary nebula inside the first one or perhaps an object something like Abell 30 or Abell 78. It is a star that astronomers could — and perhaps will — follow for a thousand years as its final years unfold.

Low-mass stars, such as the Sun and FG Sagittae will become white dwarfs at life's end. More massive stars may finish their lives violently as supernovae, exploding in a final act that spreads much of their mass through space. The remnant of the star that exploded collapses quickly, forming a neutron star. Rotating neutron stars have magnetic fields that confine a beam of radiation. When the beam passes in our direction, it appears as a pulse of radio waves or visible light, much like the flash of light seen from the rotating light of a lighthouse. Astronomers call these pulsating neutron stars pulsars. But a neutron star by itself isn't particularly peculiar. When it lies in a binary system, though, strange things can occur as with SS 433.

SS 433 is a 14th-magnitude star in Aquila (so-named because it's the 433rd object in a catalog by Bruce Stephenson and Nicholas Sanduleak). It lies in W 50, a supernova that exploded some 10,000 years ago. SS 433



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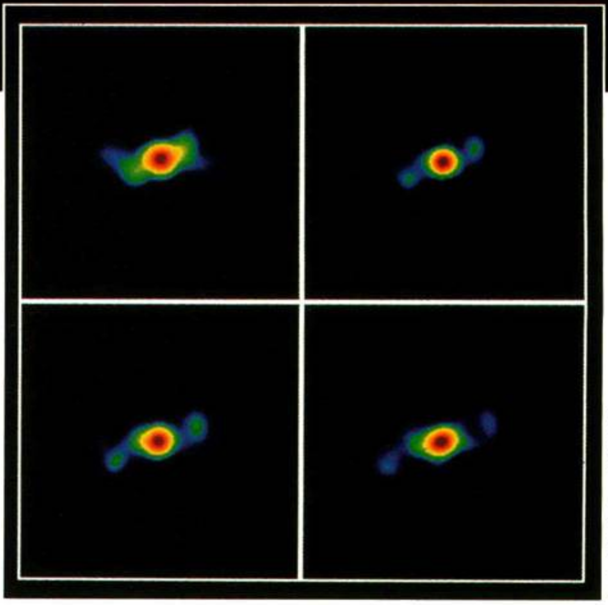
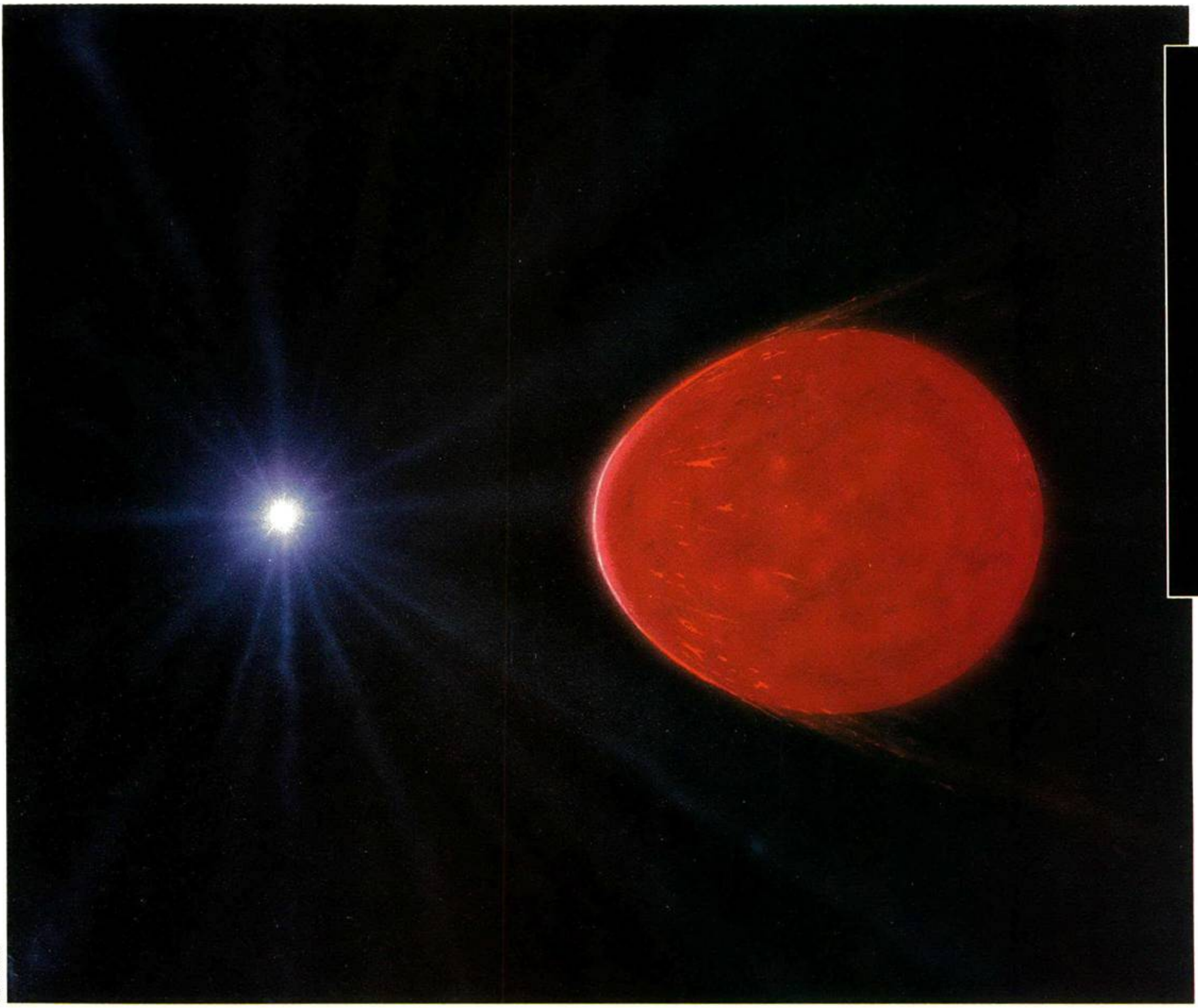


Robert Hjellming, NRAO/AUI

AS ITS COCKEYED DISK SPINS, SS 433 squirts two jets into space (top). Over a period of four years, radio astronomers could see gas from the jets expand into space (above). X-ray observations show the gas extends as far as 100 light-years from the star.



Ron Miller

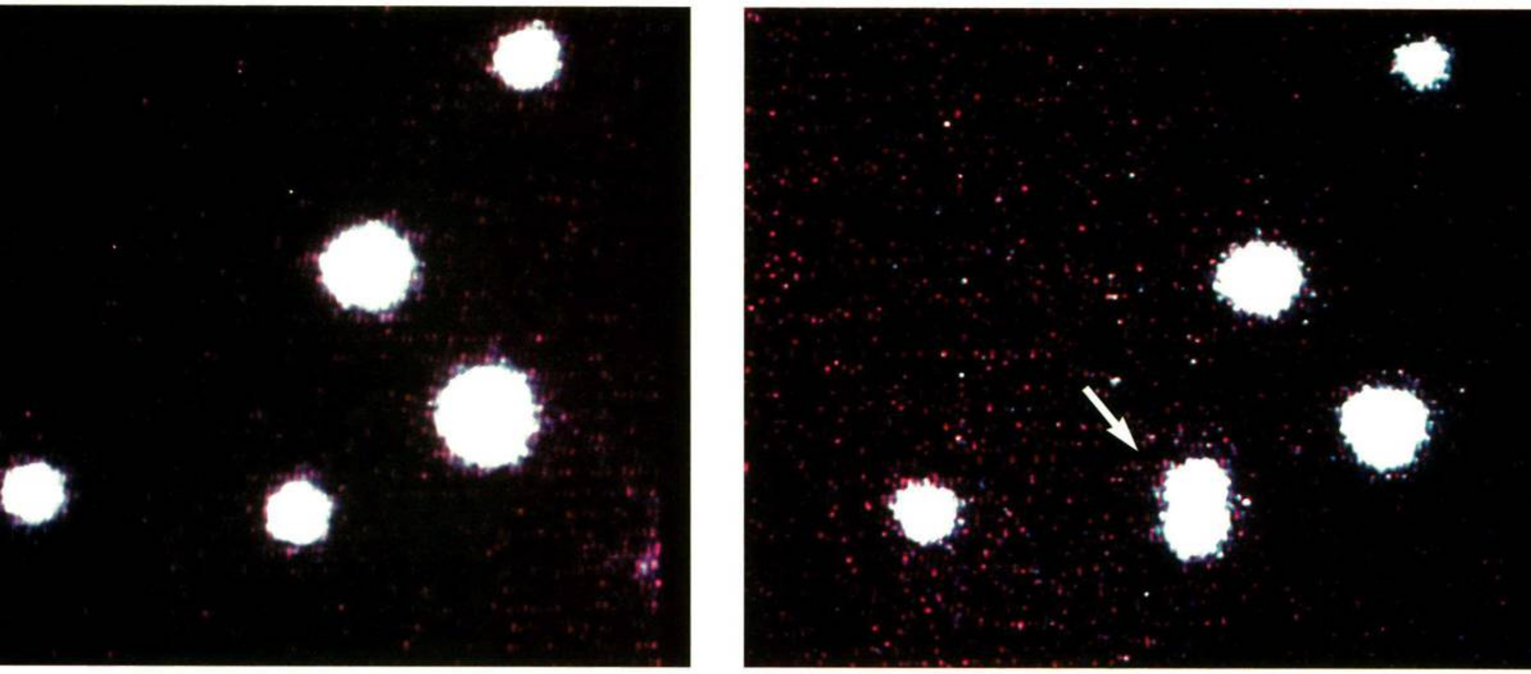
shows bright spectral lines of hydrogen and helium that shift back and forth in the spectrum, indicating that the star moves around an unseen companion every 13 days. So it's actually a binary star consisting of one star with about the Sun's mass and a second about three times more massive. The spectrum of the more massive star suggests it's a hot, bluish supergiant. The lower mass star is the brighter of the two. No Sun-like star or white dwarf could emit so much energy, so it must be a neutron star.

So far SS 433 sounds rather ordinary. What makes it an oddball is that it shows two sets of hydrogen and helium lines that move wildly through the spectrum with a period of 164 days. The changes in the wavelengths of the lines indicate that something moves at about 40,000 kilometers per second, a large fraction of the speed of light. The set of lines shifted to shorter, or bluer, wavelengths signals that gas is approaching us, while the second set shifted to longer, redder wavelengths, indicates that other gas is moving away from us.

Astronomers suspect that the gravity of the smaller star sucks some gas from the distended outer layers of the supergiant. This gas forms a disk around the neutron star. As the gas spirals toward the neutron star, some of it squirts violently into space in the direction of least resistance. We probably wouldn't see the two gas jets except that the disk tilts at a different angle than the line between the two stars. The supergiant's gravity causes the disk to wobble with a period of 164 days so the rapidly gushing jets turn wildly around in space, much as water from a twirling water hose, producing the wild motions of the spectral lines.

The violent motions in the jets have a profound effect on the star's immediate environment. Radio observations made with the Very Large Array outside Socorro, New Mexico, show corkscrewing gaseous streams a few arcseconds across, as would be expected from the swinging beams of gas. These align with a bar of X-ray emission that appears nearly 1° long. At the object's distance of about 15,000 light-years, the X-ray emission indicates that the jets reach a distance of over 100 light-years from the star. This amazing reach makes SS 433 one of a kind.

For all its energetics, the effect of SS 433 on its companion is small compared with what other neutron stars can do. Young pulsars spin rapidly — the one in the Crab Nebula (M1) in Taurus spins 30 times per



Jan van Paradijs/William Herschel Telescope

BY DESTROYING ITS COMPANION, the Black Widow Pulsar spins faster and rejuvenates its once depleted supply of energy (left). The pulsar's intense radiation heats one side of the companion. As the companion orbits the pulsar, this side turns away from us and causes the companion to disappear (above).

second — and produce radiation in the visible part of the spectrum. This intense radiation saps a pulsar's energy, so as the star ages it slowly winds down, producing radiation in the radio part of the spectrum. Eventually the slowing pulsar disappears from view.

A handful of neutron stars rotate with truly amazing speeds. The fastest of these millisecond pulsars has a period of 0.0016 second (or 1.6 milliseconds). Imagine a star having twice the Sun's mass but a diameter of only 30 kilometers that spins over 600 times a second! The rotational speed at the star's equator is 30,000 km/s, or 10 percent the speed of light. Astronomers first thought that these fast-rotating pulsars were young. But they found that their magnetic fields had decayed, suggesting instead that the pulsars are old.

One clue to solving this age paradox came from pulsars in binary systems. Ordinary pulsars are decidedly single stars, but millisecond pulsars occur mostly in binary systems. Astronomers readily understood how a binary can produce the rapid spin of a millisecond pulsar. The star forms as do all pulsars in a supernova explosion, first spinning at high speed and then slowing down and disappearing from view. As the companion ages, however, it loses some of its mass to the pulsar. The material speeds up as it nears the pulsar and then rains down onto the pulsar's surface. The high velocity of the material forces the pulsar to speed up and the resultant energy imparted to the star causes the pulsar to rejuvenate.

But PSR 1937+21 (the numbers refer to its position in the sky, which is in Vulpecula), the first millisecond pulsar found, is clearly single. It cast doubt on this simple picture of how millisecond pulsars form until astronomers found another millisecond pulsar. PSR 1957+20 in Sagitta is not only a binary but an eclipsing binary. Radio signals from the pulsar cut off for 20 minutes every 9.2 hours as the neutron star passes behind its neighbor. At the same time, its companion star disappears as well.

The disappearance of both stars simultaneously stumped researchers until they realized that the companion's light wasn't its natural radiation. Rather, the pulsar's fierce radio blast heats one side of the companion star. When the pulsar passes behind the companion, the companion blocks the pulsar's radiation and its heated side faces away from us, thus disappearing from view.

From the orbital motions of the pair, astronomers have found that the companion has a mass only about 20 times that of Jupiter — far too small to be a star. The length of the eclipse, though, shows it is large, about the diameter of the Sun. The radio signals from the pulsar also reveal that gas surrounds the companion, indicating that the companion is evaporating before our eyes. The pulsar is ablating rather than accreting its mate. This bizarre behavior led astronomers to call it the Black Widow Pulsar. A similar action must have destroyed the mass-giving star in the lone single millisecond pulsar, PSR 1937+21.

Epsilon Aurigae, FG Sagittae, SS 433, the Black Widow Pulsar — the list of oddball stars is far from exhausted. Giant spotted stars, stars with powerful magnetic fields, and stars that literally tear themselves apart as they spin rapidly could also make the list of oddballs. But one star is perhaps the most peculiar of all: the Sun. It's the only star we know with a planet that has liquid water on its surface, oxygen in its atmosphere, and supports a thing called life — the life that allows the appreciation and comprehension of this remarkable bestiary of stars and of the wonderful construction we call the universe. □

James Kaler, a professor of astronomy at the University of Illinois, has written many articles for Astronomy, *including "Hypergiants" (March 1994).*

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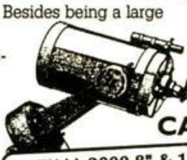

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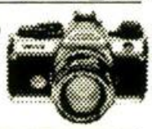

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SKY ALMANAC

September 1994

Saturn Comes to Opposition

The Ringed Planet reaches opposition in September, making it opposite the Sun in the sky and ideally placed for observing. Telescopes in the 4-inch to 8-inch range will show the planet's tawny yellow globe encircled by unmistakable rings. Observers equipped with larger scopes and fortunate enough to have steady seeing may see subtle features on the planet's globe.

Comet Borrelly Moves Through Orion

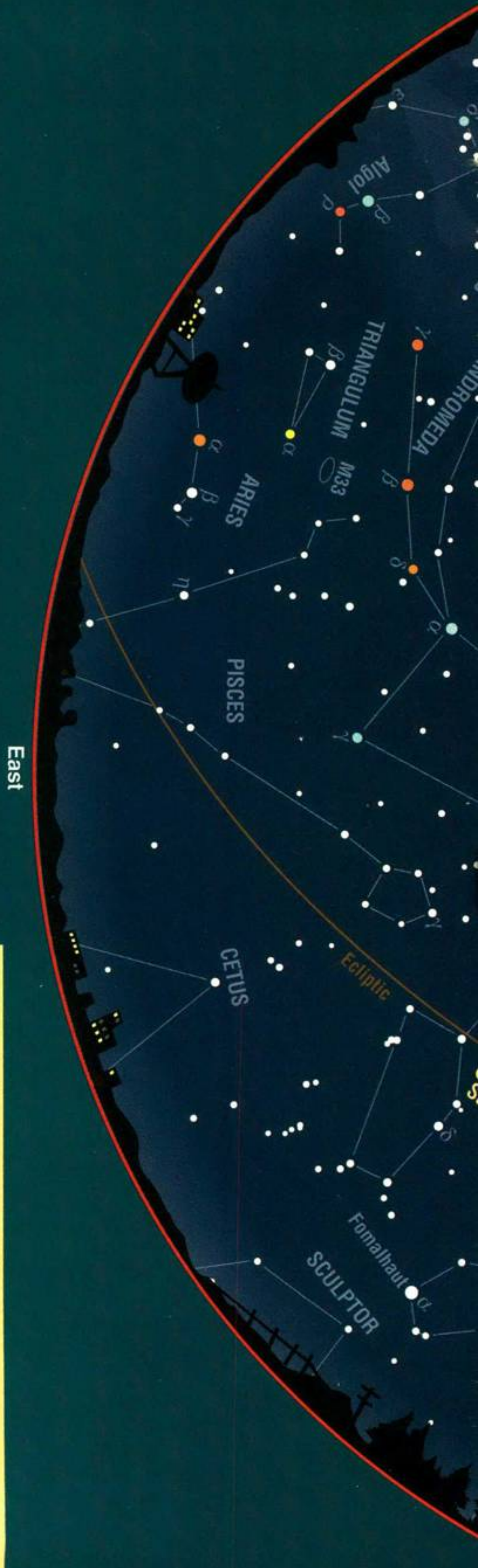
One of the year's brightest comets slowly slides across southern Orion this month, making an attractive target for binoculars and small telescopes. Glowing at magnitude 8.5, the comet will pass just north of the Orion Nebula on the 14th and just south of the Horsehead Nebula on the 17th.

The Moon Passes Venus

On the evening of September 8, the pretty light of the Moon passes just 2° north of the brilliant planet Venus. The pair will hang low in the western sky as twilight deepens, providing astrophotographers with a grand opportunity for shooting nightscapes showing the Moon, Venus, and the horizon.

The Light of the Harvest Moon

On the night of the 19th, the Full Moon spreads light over the landscape. It is called the Harvest Moon because traditionally farmers used its light to harvest crops. It offers backyard astronomers a great subject for binoculars and cameras.



CALENDAR OF EVENTS

1 Saturn is at opposition, 1 p.m. EDT

5 New Moon is at 2:33 p.m. EDT

8 Venus is at aphelion
The Moon is at perigee (226,892 miles from Earth), 10:25 a.m. EDT
The Moon passes 2° north of Venus, 9 p.m. EDT

9 The Moon passes 1.4° south of Jupiter, 4 p.m. EDT

12 First Quarter Moon is at 7:34 a.m. EDT

15 Mercury is at aphelion

18 The Moon passes 7° north of Saturn, 9 a.m. EDT

19 Full Moon, "Harvest Moon," is at 4:00 p.m. EDT

21 Mercury passes 0.1° south of Spica, 9 a.m. EDT

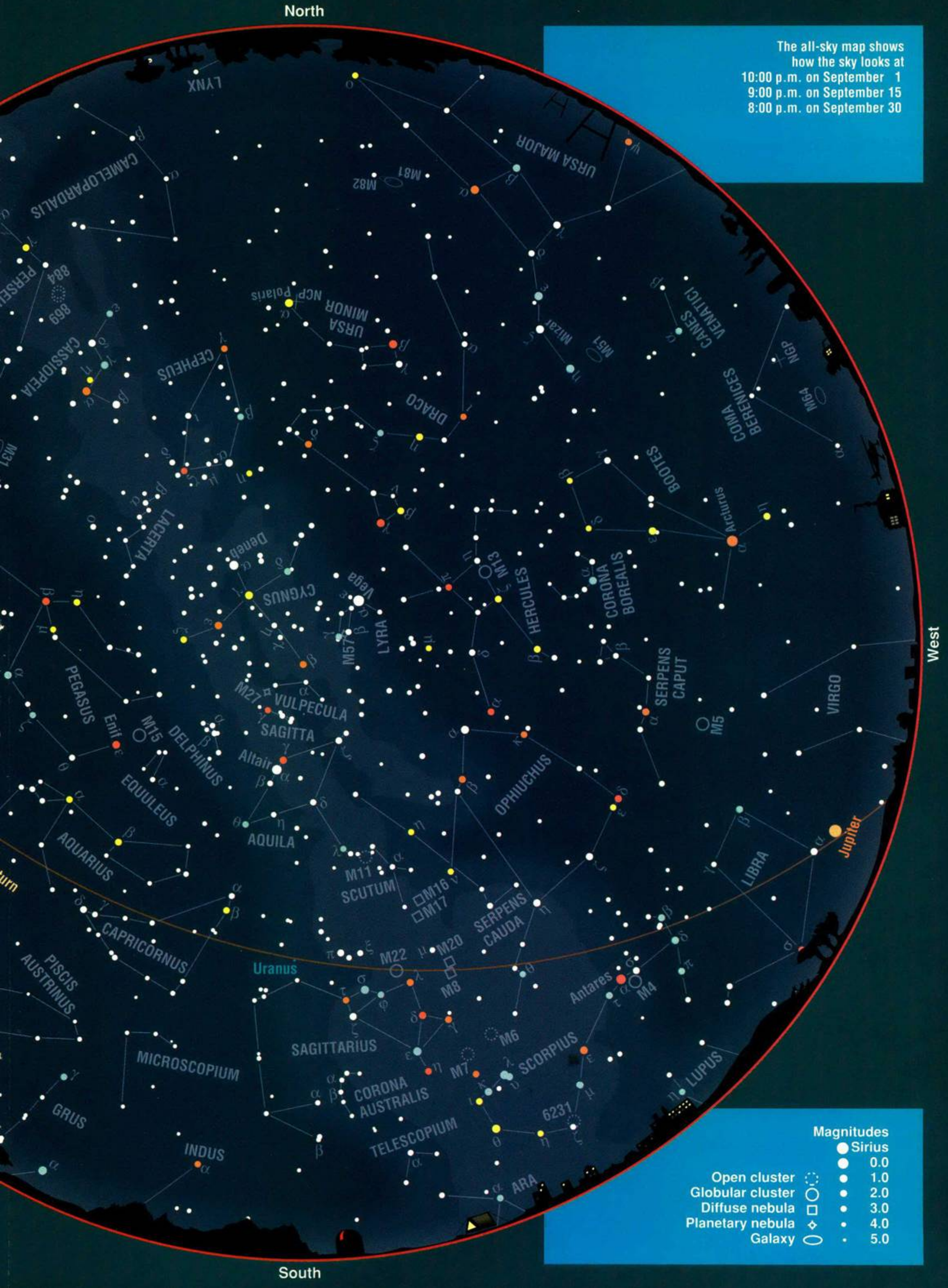
23 Autumnal equinox is at 2:19 a.m. EDT

24 The Moon is at apogee (251,808 miles from Earth), 8:04 a.m. EDT
Mars passes 6° south of Pollux, 11 a.m. EDT

26 Mercury reaches greatest eastern elongation (26°), noon EDT

27 Last Quarter Moon is at 8:23 p.m. EDT
The Moon passes 0.06° south of Vesta, 11 p.m. EDT
Venus is at greatest brilliancy (magnitude –4.6), 6 p.m. EDT

The all-sky map shows
how the sky looks at
10:00 p.m. on September 1
9:00 p.m. on September 15
8:00 p.m. on September 30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Mizar
M51
CANES VENATICI
NGP
M64
COMA BERENICES
DRACO
M31
BOOTES
Arcturus
LACERTA
Deneb
CYGNUS
Vega
M13
HERCULES
CORONA BOREALIS
LYRA
M57
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SERPENS CAPUT
M5
VIRGO
West
Enif
M15
DELPHINUS
Altair
EQUULEUS
OPHIUCHUS
AQUILA
AQUARIUS
Jupiter
LIBRA
Saturn
M11
SCUTUM
M16
M17
SERPENS CAUDA
CAPRICORNUS
M22
M20
Uranus
M8
Antares
M4
PISCIS AUSTRINUS
SAGITTARIUS
M6
SCORPIUS
MICROSCOPIUM
M7
LUPUS
CORONA AUSTRALIS
GRUS
6231
TELESCOPIUM
INDUS
ARA
South

Magnitudes
● Sirius
● 0.0
● 1.0
● 2.0
● 3.0
● 4.0
● 5.0

Open cluster ⁚
Globular cluster ○
Diffuse nebula □
Planetary nebula ⌖
Galaxy ⬭

SKY ALMANAC

by Deborah Byrd and Jeff Kanipe

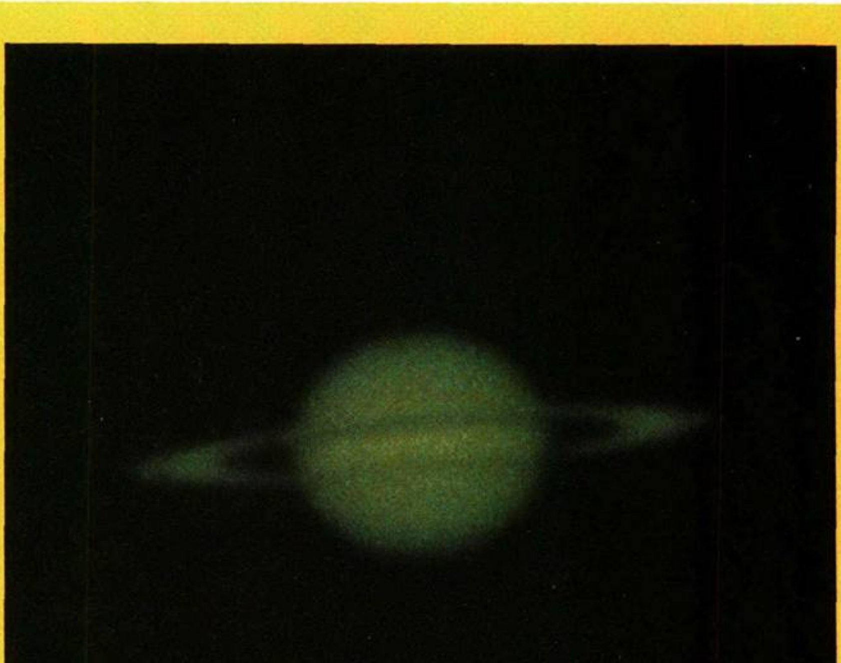
An exciting event awaits skywatchers on the first day of this month when Saturn comes to opposition and appears to the eye as a steady, golden point of light opposite the Sun in our sky. Saturn then rises in the southeast at sunset and is highest in the southern sky around midnight. The planet is closest to Earth for this year, and as a result it appears brightest for the year, at magnitude 0.5.

Saturn comes to this location in our sky due to Earth's motion around the Sun. Our motion in orbit carries us between Saturn and the Sun once a year. Saturn moves around the Sun, too, but its "year" lasts 29 of our years. The orbital motion of the ringed planet serves only to place it a little farther east in our sky at each subsequent opposition.

This year Saturn comes to opposition against the starry backdrop of Aquarius. It's not far from the bright star Fomalhaut in the constellation Piscis Austrinus. At magnitude 1.2, Fomalhaut is fainter than Saturn, the faintest of the four bright naked-eye planets now visible in the evening sky, but a telescope reveals it as a complex system of orbiting rings and moons. Its largest moon, Titan, appears as an 8th-magnitude point near the planet. Saturn's rings are now only 7° from being precisely edge-on as seen from our vantage point. As the planet moves in orbit, the rings undergo a cycle during which they appear first more and then less open to us. When they appear wide open, the rings contribute to Saturn's overall brightness. Now they are

Saturn Reaches Opposition

September twilight finds Saturn shining through the trees above the east-southeastern horizon. By nightfall it is fairly high and bright and approaching optimal viewing altitude. This year marks the first time in over a decade that Saturn has edged so far north along the ecliptic. At opposition on September 1, the planet is at a declination of –10° compared with –22° in 1988 and 1989. The planet's more northerly position means it will be much less affected by atmospheric turbulence than it would be if it were lower in the sky and so should provide northern observers sharper views through the telescope.


Jean Dragesco

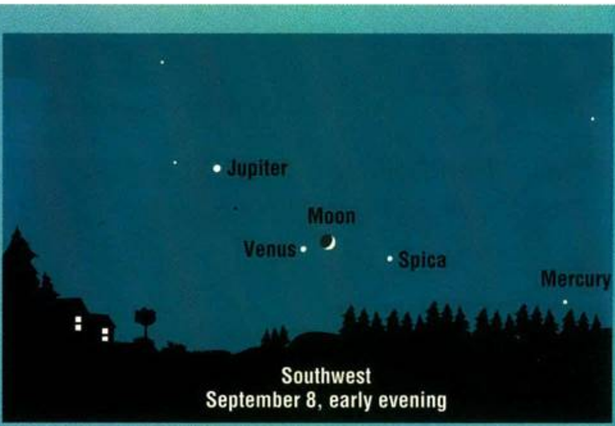
Telescopes in the 4- to 8-inch range should have no trouble spotting the narrow shadow of the rings cutting across the equatorial region of the globe, but little of the globe's shadow across the backside of the rings will show. At opposition, viewers should see Saturn fully lit from the front. In the coming weeks, however, watch this angular shadow increase as Earth shifts out of alignment between Saturn and the Sun.

More challenging than the rings are the white spots in the planet's atmosphere in or near the equatorial belt. Except for the occasional outburst (like the one that occurred four years ago this month), Saturn rarely displays overt atmospheric features. You need at least a 4-inch telescope, moderate magnification, patience, and windows of good seeing to spot these subtle, low-contrast features.

If the seeing is good, try looking for Saturn's brightest moons. Titan, Saturn's largest, is an easy object in any telescope, shining at 8th magnitude. It can be found as much as five ring diameters off to one side of the planet. Closer in are three others that are normally visible in at least a 4-inch telescope. The brightest of these is Rhea, at magnitude 9.7, followed by Tethys and Dione (10.3 and 10.4, respectively). Iapetus is the oddball moon. When it is west of the planet it can be seen at magnitude 10.1 some twelve ring diameters from the planet. But at eastern elongation it shows a darker side and dims to magnitude 11.9.

If you haven't looked at the planet in some time, you may be surprised to see that the rings have flattened out considerably. The tilt of Saturn's axis relative to Saturn's orbit carries our line of sight through Saturn's ring plane every 15 years, on average. Another ring plane passage will occur 8 months hence on May 22, 1995.

The Moon and Venus Form a Pretty Pair



Astrophotographers who specialize in celestial-terrestrial combination shots will want to be ready the evening of the 8th when Venus, approaching its peak magnitude for the year, stands 2° north of the slim crescent Moon in the western twilight sky. Planet observers have noted Venus flirting with the Moon once a month all year: 3° last month, 4° in May. It came closest last April 12 when the –3.9-magnitude planet stood 1° south of the crescent Moon.

This month's configuration is just as eye-catching because Venus is noticeably brighter now (magnitude –4.5) than it was five months ago. Use binoculars to appreciate the whole Venus-Moon effect. And bear in mind that you're looking at stepping stones in space: the Moon, at a distance of 227,000 miles and Venus lying beyond at a distance slightly greater than 53 million miles.

Seeing Double in Cygnus

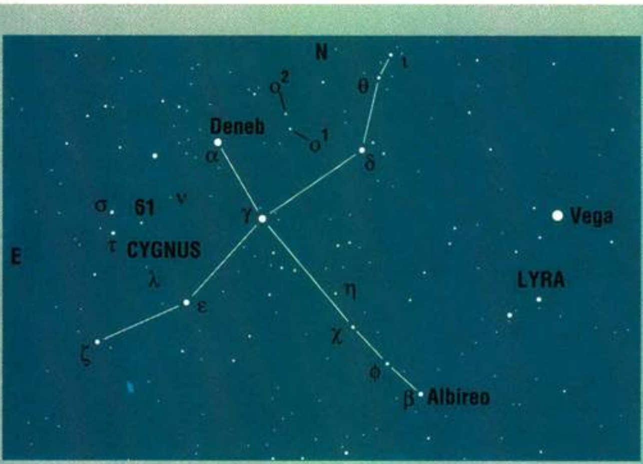
The most popular double star in Cygnus, Beta (ß) Cygni, or Albireo, was called "one of the finest sights in the heavens" by the great 19th-century observer T. W. Webb. In almost any size telescope the stars appear to be a golden yellow and a deep blue of magnitudes 3.1 and 5.1, respectively. With a separation of 34.4", the stars are easy to distinguish both by their magnitudes and colors. Even 10x50 binoculars can split this pair if you look carefully.

A striking binocular double (although not a true binary) lurks in Omicron (o) Cygni, which lies due west of Deneb in a dark band of the Milky Way. Their colors have been reported variously as pale and golden yellow to light blue-green.

A challenging telescopic double is Mu (μ) Cygni, which lies in the southeast region of Cygnus. Mu consists of a pair of white stars at magnitudes 4.8 and 6.1. With a separation of only 1.5", it takes a 6- to 8-inch scope and steady seeing to resolve it.

Splitting the stars of Delta (δ) Cygni is another challenge. Although their separation is greater (2.4"), the stars differ greatly in magnitude. The main component shines at magnitude 2.9, while the companion glows softly at magnitude 6.3. A 6-inch scope should resolve them.

Finally, 61 Cygni offers a striking pair of orange-tinted stars of magnitudes 5.2 and 6, with a separation of nearly 30". Both stars are easily resolved in a small telescope.



61 Cygni

Alfred Lilge

Albireo

John Sanford

Shine On, Harvest Moon

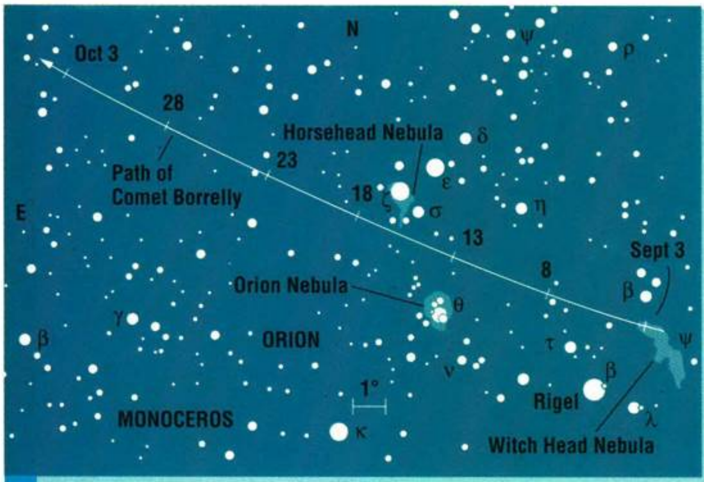
Dewey Vanderhoff

Monday evening the 19th of September, the Full Moon will rise slowly above the trees, casting its warm yellow glow over the land like a great Chinese lantern. This Moon is known for the light it provided harvesters as they worked into the evening hours to get in their crops before winter — hence its name, the Harvest Moon.

The Full Moon dominates the evening sky this time of year. The reason is simple: the geometry of the Sun, Moon, and Earth. As Earth orbits the Sun over the course of the year, the Sun traces a path against the background stars, called the ecliptic. Because the Moon's orbit around Earth lies in nearly the same plane as Earth's orbit around the Sun, the Moon follows a path very close to the ecliptic. On September 23, the first day of autumn, the Sun's position on the ecliptic is at the autumnal equinox, the point where the Sun crosses from the northern half to the southern half of the sky.

Because the Full Moon always lies opposite the Sun in the sky, in early fall it finds itself near the vernal equinox (the Sun's position on the first day of spring). This part of the ecliptic makes a very shallow angle to the eastern horizon. So, as the nearly Full Moon travels eastward along the ecliptic, it doesn't drop as far below the horizon from one evening to the next as it does at other times of the year. Thus Earth doesn't have to rotate as far to bring the Moon above the horizon, and moonrise times from night to night don't vary much.

The angle of the ecliptic to the horizon also varies with latitude. Where this angle is steepest — in the tropics — the effect is not very noticeable. At higher latitudes, though, where the angle of the ecliptic is much shallower, the effect is dramatic. For example, at a latitude of 40° north, the daily differences in moonrise times average about 30 minutes rather than the typical 49 minutes. At 50° north, the difference dwindles to about 23 minutes, and at 60° north the difference amounts to little more than 10 minutes.



Comet Borrelly Glides Through Orion

Now's a good time to locate and track what may be the year's most prominent periodic comet, Comet Borrelly, especially if you want to follow it as it climbs toward peak brightness in November. This comet is expected to be as bright as Comet Encke was last February, but it is much better placed.

Borrelly has been arching out of the southern sky since January, when it was well below the ecliptic plane. In May, however, Borrelly seemed to pick up speed as Earth began closing in on the comet and we could see it making steady progress. Currently Borrelly is moving northeastward through southern Orion. It passes just north of the Orion Nebula on September 14 and just south of the Horsehead Nebula on the 17th. It moves into Monoceros by late-September. The comet's visual magnitude at the beginning of the month is around 10, brightens to 9.6 by midmonth, and reaches 9.0 by month's end. Although it passes through a rather rich region of the sky, Borrelly should stand out among the stars as a fairly compact patch of greenish-white light. Be sure to look for flaring in the coma or evidence of a tail.

One caveat. Being an extended object, Borrelly will be somewhat fainter than its visual magnitude implies. An extended object's brightness is measured by its integrated magnitude — the magnitude it would have if all its light could be consolidated into a point source. Hence, although its stated magnitude may be 9, remember that this is an integrated magnitude. Look instead for an object with a somewhat lower surface brightness.

COORDINATES FOR COMET BORRELLY

Date	R.A. (2000)	Dec.	Mag.
Sept. 3	5h07.8m	–6°07'	10.3
Sept. 8	5h20.6m	–5°05'	10.0
Sept. 13	5h33.3m	–3°58'	9.8
Sept. 18	5h46.1m	–2°45'	9.6
Sept. 23	5h58.9m	–1°26'	9.4
Sept. 28	6h11.7m	0°01'	9.2
Oct. 3	6h24.6m	1°36'	9.0

nearly edge-on, and as a result Saturn is fainter at opposition than it was last year, even though the planet is closer to us this year.

Twice in each orbit of Saturn, the rings appear precisely edge-on with respect to Earth. The rings are so thin that at such times they cannot be seen. Such will be the case next year, so now is the time for telescopic observers to note color and brightness differences between the A and B rings. Also, turn your attention to Saturn's globe. The first impression is that of a golden, featureless world. A closer inspection may reveal a darker polar region, and perhaps some very subtle shading.

Even more featureless is the brilliant planet Venus, which towers over the western horizon after sunset. Greatest brilliancy for Venus comes on September 28, when the planet shines at –4.6 magnitude. On September 8, the young Moon passes close to Venus in the western twilight sky. A glance outside each successive evening will show the Moon waxing toward Full. A look each evening at the same time — perhaps just after sunset — reveals the Moon situated farther to the east each evening. This eastward trek across the sky from night to night is due to the Moon's motion in orbit around Earth.

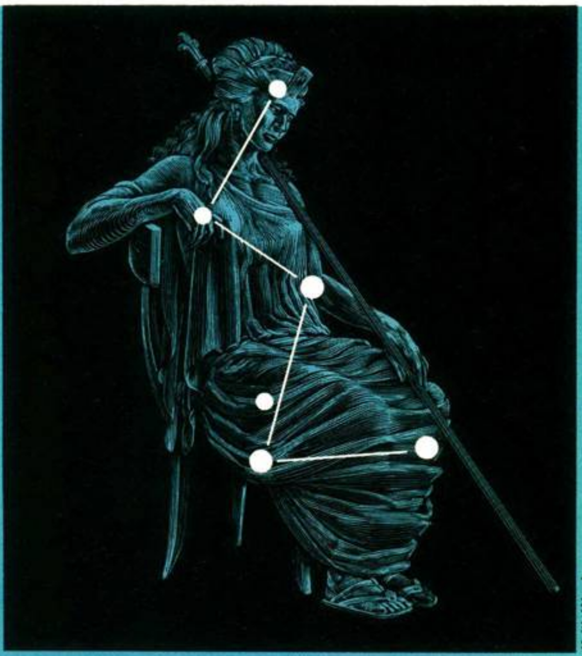
By the night of September 19, the Moon is Full. This is the Full Moon closest to the autumnal equinox — which comes this year on September 23 — and thus it is called the Harvest Moon. The Harvest Moon rises around sunset for several evenings in a row, and it appears completely or nearly full on each of those evenings.

Two notable comets wander across the sky this month, Borrelly and Harrington. Comet Borrelly moves across the southern part of Orion, passing just north of the Orion Nebula on the 14th and just south of the Horsehead Nebula on the 17th. Borrelly glows slightly brighter than 10th magnitude, making it visible easily in binoculars. Comet Harrington, fainter at about 12th magnitude, moves slowly through Cetus south of the variable star Mira.

This month's asteroid is the 20th one to be discovered, with the proper name of Massalia. It shines at magnitude 9.5. Look for it as it wanders through Pisces.

THE STARRY SKY

by Deborah Byrd



Keith Ward

Stand outside on a clear evening and face the northern sky and you'll notice a bright pattern of stars that looks like the letter "W" or "M." This is Cassiopeia, the Queen, which most people see as five bright stars. Some of these stars are named for the Queen's anatomy. Alpha Cassiopeiae is called *Schedar*, meaning "the breast." Beta is *Caph*, or "the hand." Delta, or *Ruchbah*, is "the knee." This pretty group of stars offers naked-eye viewers a fine, recognizable pattern. Telescopic observers know Cassiopeia for its rich collection of star clusters.

From the northern United States, Cassiopeia is a circumpolar constellation. This means it neither rises nor sets, but instead circles endlessly around Polaris, the star near the North Celestial Pole. Cassiopeia lies on the exact opposite side of Polaris from the Big Dipper. Imagine the northern sky as a giant clock with Polaris in the center: when Cassiopeia appears at 3 o'clock, the Dipper is at 9 o'clock. These two great star patterns move in a counterclockwise direction around the celestial pole.

In Greek mythology, Cassiopeia represents the Queen of Ethiopia, part of the Royal Family of the heavens. Her husband is King Cepheus, and her daughter is Princess Andromeda. Star lore states that Cassiopeia offended the nereids, or sea nymphs, when she boasted that her beauty was greater than theirs. The nymphs complained to Neptune, god of the sea, who sent a monster to ravage the coast of Ethiopia and also demanded a sacrifice of Andromeda. The princess was ultimately rescued by the hero Perseus, but the sea nymphs had their revenge. They caused Cassiopeia to be bound to a chair and placed in the northern sky. As the queen revolves around Polaris, she sometimes hangs from the chair in a humiliating, upside-down position.

As we see her in the sky, Cassiopeia lies in front of the winter Milky Way in the direction approximately opposite the star-rich center of the Galaxy. The Milky Way appears sparser here than in Sagittarius, but this area provides a rich hunting ground for scanning the heavens with binoculars or a rich-field telescope.

As you explore Cassiopeia, take note of the middle star in the "W." Gamma Cassiopeiae is a peculiar variable star known for its unpredictability. Steady at magnitude 2.2 until 1936, Gamma then gradually increased in brightness until, in the following year, it was as bright as 1st-magnitude Deneb. Later the star dropped to about magnitude 3.0 and then rose again to magnitude 2.5, where it remains today.

Another famous star appeared in Cassiopeia more than four hundred years ago. After a lifetime beneath a firmament believed to be unchanging, the Danish astronomer Tycho Brahe glanced up on November 11, 1572, and noticed a "new star." It became brighter than Venus and for two weeks was visible in full daylight. Tycho studied it carefully for 17 months, until it faded entirely from view. Today, no sign of the star itself remains, but shreds of nebulosity visible on photographic plates betray a legacy of the galactic cataclysm we know as Tycho's Star.

September's Planets

Mercury graces the evening sky this month, with greatest elongation on September 26. The narrow angle of the ecliptic to the horizon, however, will probably prevent you from seeing it. Meanwhile, a brilliant object stands higher than Mercury in the western twilight sky. **Venus** is near the bright star Spica when the month begins, but the planet steals the show by shining brilliantly at magnitude −4.4 when the month begins. Venus is a dazzling sight near the young Moon on September 8. Greatest brilliancy for Venus comes on September 28, when the planet's magnitude is −4.6.

Some observers believe Venus is brightest when we see a fully illuminated disk, but that's not the case. Greatest brilliancy for Venus stems from a combination of factors, including its nearness to Earth and the percentage of its lighted half that faces our direction. It seems paradoxical to think that Venus appears brightest while showing us less of its lighted half, but that's the case. If you peer at Venus through a telescope this month, you'll see it as a waning crescent globe.

Yet another bright planet lies in this part of the sky. **Jupiter**, the solar system's largest planet and the second-brightest planet after Venus, shines at magnitude −1.8. Located in the constellation Libra, the King of planets starts out about 15° to the upper left of Venus on September 1 and sinks toward the brighter planet as the month passes. It is near the young Moon on September 9. Who knows what a telescope will reveal on this planet this month? Jupiter may still be suffering from disturbances spawned in late July, by the multiple impacts of the fragmented Comet Shoemaker-Levy 9.

Pluto, in Libra, is up in the southwest after sunset. It shines at magnitude 13.8. **Uranus** and **Neptune**, both in Sagittarius, lie in the south after sunset this month. Uranus glows at magnitude 5.7 and Neptune at 7.9.

Because it's opposite the Sun this month, **Saturn** appears near another object opposite the Sun, the nearly Full Moon. Look for Saturn near the Moon on September 18. The Moon is Full the following day.

Mars comes up a couple of hours before the Sun this month and can be found in the east before dawn. The waning crescent Moon is just below Mars on September 1. In early September, Mars stands at the feet of Gemini, and the stars of this constellation rise up behind the planet as the month passes. By the month's end, Mars appears aligned with Castor and Pollux, the two brightest stars of Gemini. The Moon joins the trio on the morning of September 29. □

Deborah Byrd produces the monthly "Earth and Sky" radio program. Jeff Kanipe edits Star Date *magazine.*

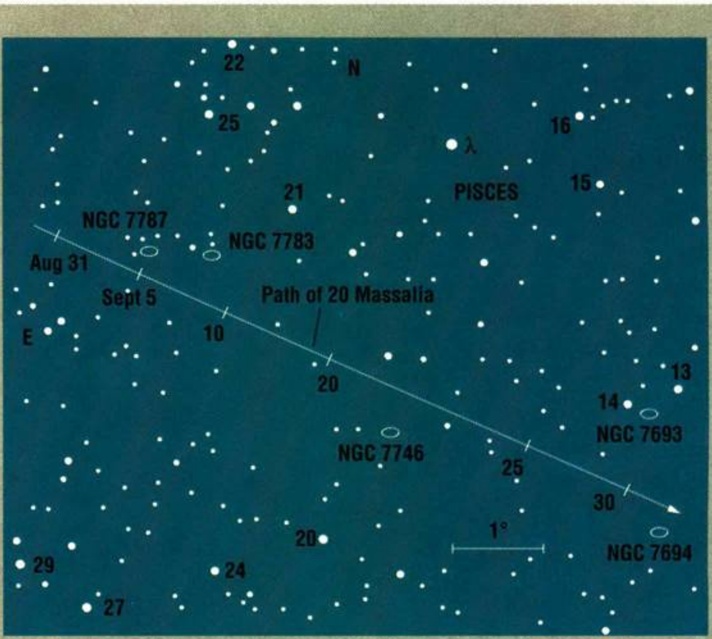
Keeping Tabs on Asteroid 20 Massalia

Now skirting through the watery constellations of Pisces, the Fish, and Aquarius, the Water Carrier, is the 82-mile-diameter minor planet 20 Massalia. The asteroid is at opposition on September 18, when it reaches magnitude 9.4. Massalia spends the entire month slipping southwestward beneath the circlet of Pisces.

The asteroid's daily motion is modest at best, and during the month the asteroid doesn't transit more than about 5° of sky. Fortunately, this part of Pisces and Aquarius is not a particularly star-rich region of sky, which should make finding 20 Massalia an easier task than it would be in a field powdered with stars. There's a nice kite-shaped asterism of four 6th-magnitude stars east of the circlet that you can easily see in binoculars. This makes a nice marker for the first 10 days of September because 20 Massalia is located only about a degree south of it.

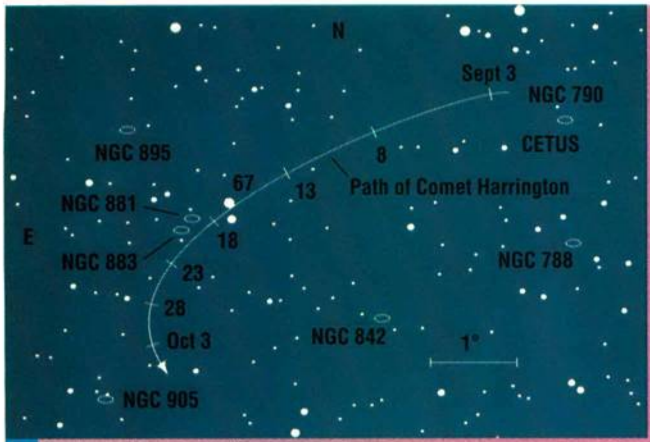
Use the finder chart to help target the asteroid on the day you begin your search. Use an eyepiece that yields no more than a 1° field of view. If the field of view is too big, the asteroid can get lost and its motion won't be very apparent; if too small you limit your search area.

Center the field of view on the region and carefully sketch all the stars to be seen. Come back a night or two later and compare the sketch with the view in the eyepiece. The "star" that has moved relative to the background stars is 20 Massalia. Although it's easier to spot the asteroid's motion over a day or two, this region of sky remains above the horizon essentially all night. So if you enjoy your stargazing in all-night doses, try spotting its motion from early evening to late morning.



ASTEROID 20 MASSALIA POSITIONS

Date	R.A. (2000)	Dec.	Mag.
Aug. 31	0h00.0m	0°44'	9.9
Sept. 5	23h56.3m	0°19'	9.8
Sept. 10	23h52.2m	−0°09'	9.7
Sept. 15	23h47.8m	−0°38'	9.5
Sept. 20	23h43.2m	−1°09'	9.4
Sept. 25	23h38.7m	−1°40'	9.5
Sept. 30	23h34.2m	−2°11'	9.6



COORDINATES FOR COMET HARRINGTON

Date	R.A. (2000)	Dec.	Mag.
Sept. 3	2h05.0m	–5°02'	12.8
Sept. 8	2h10.3m	–5°32'	12.7
Sept. 13	2h14.5m	–6°04'	12.7
Sept. 18	2h17.5m	–6°36'	12.7
Sept. 23	2h19.5m	–7°08'	12.7
Sept. 28	2h20.5m	–7°37'	12.7
Oct. 3	2h20.4m,	–8°2'	12.7

Follow Comet Harrington

Just past perihelion (August 23), Comet Harrington is now diving south through Cetus, well below the ecliptic plane. This little comet, discovered in 1953 by Robert Harrington, has a period of 6.7 years and has been well observed during the last two apparitions in 1980 and 1987. It wasn't observed in 1967 or 1974, however, because it came to perihelion behind the Sun. Unfortunately, Harrington isn't the showstopper Borrelly is but, hey, challenge yourself! You may want to do your own comet searches some day and many new comets are about as bright as Harrington is at its peak: magnitude 13.

Harrington's apparent motion is decreasing as Earth overtakes it. It will loop back briefly into retrograde motion and then move on to the northeast, edging north of Mira. This part of the sky rises just after sunset, and by mid-October it rises at sunset. The comet reaches opposition on October 21 but by then is fading fast. Go out and see Harrington sooner than later.

Spot M33 with the Naked Eye

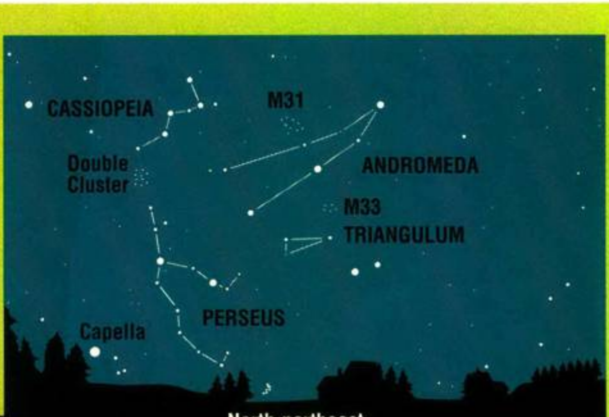
One of the longstanding debates in deep-sky observing is whether or not it is possible to see the galaxy M33 with the naked eye. It is, given the right conditions.

M33 can be devilishly difficult to locate in a telescope, so why should it be easier to spot with the naked eye? Its given magnitude is 5.7, which already puts it near the theoretical naked-eye limit. But take into account that it is spread out over an area of sky greater than the apparent diameter of the Full Moon and thus has an even lower surface brightness than its magnitude implies.

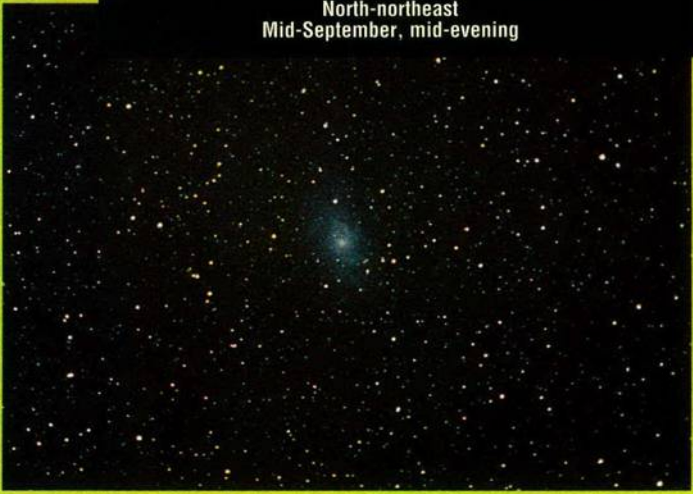
Still, by virtue of the contrast effect between the dark surrounding sky and the somewhat brighter M33, you should be able to detect its presence, just as you would hear the proverbial pin drop in a quiet room. Furthermore, because the source is compact compared to the surrounding sky, it will appear more concentrated and brighter to the eye.

To find M33, first locate the Great Square of Pegasus, which lies well up in the east on autumn evenings, and from there look for the bright star Beta (β) Andromedae. Coincidentally, Beta also serves as a marker star for the only other galaxy in the Northern Hemisphere that can be seen with the unaided eye, the Andromeda Galaxy (M31). Now let your eye draw an imaginary line south and east from Beta Andromedae to Alpha (α) Trianguli, the apex star of the Triangle. Just south and east of the midway point of this line, closer to Alpha Trianguli, lies M33.

With fully dark adapted eyes and observing from a dark site on a night of good transparency — which is more probable in October than September — you may detect a faint oval patch, a slight enhancement in the sky background. That is M33. Too much moisture in the atmosphere will scatter the light even more and you won't see anything; too much extraneous light will dampen it right out. And without fully dark adapted eyes, you won't detect the contrast difference at all. Conditions must be just right.



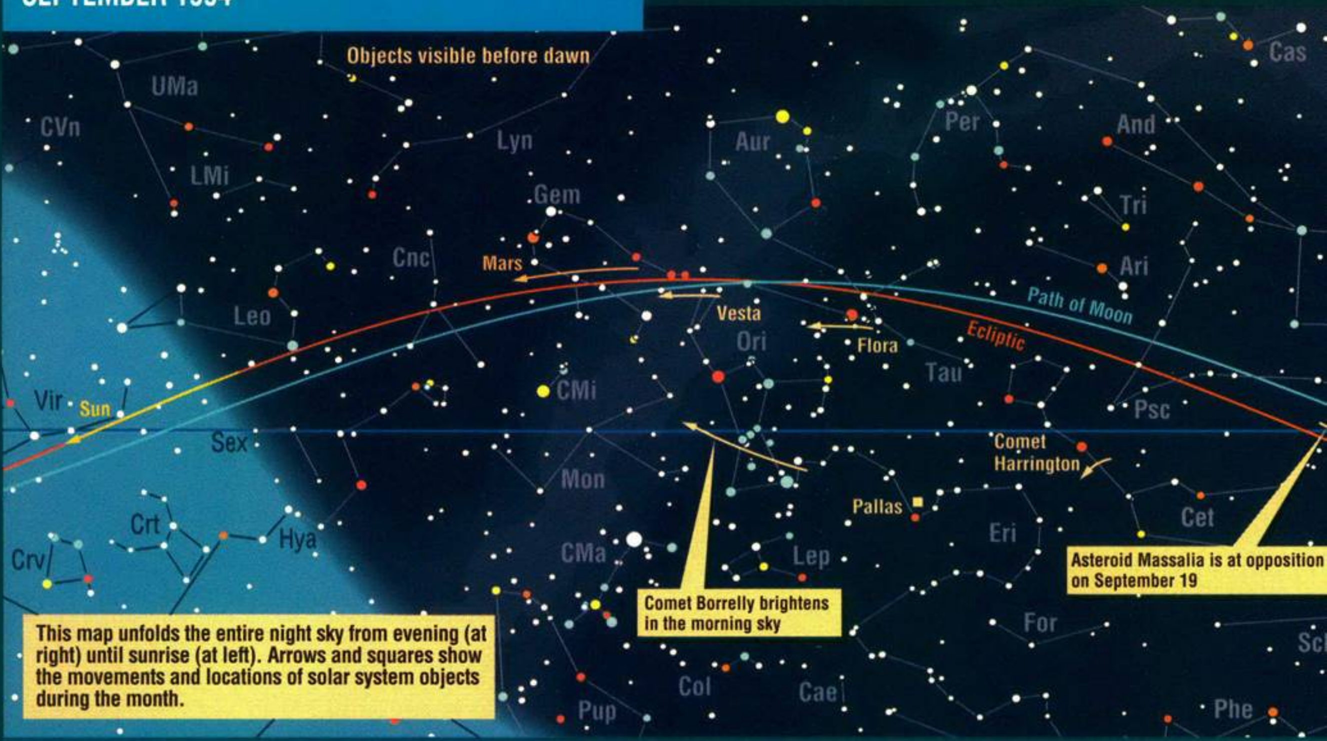
North-northeast
Mid-September, mid-evening



Glen Deen

SKY ALMANAC

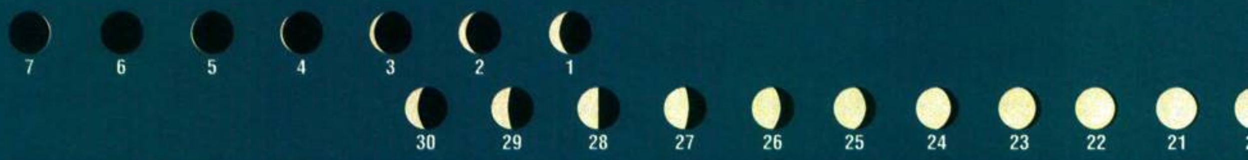
SEPTEMBER 1994


Objects visible before dawn
Cas
UMa
CVn
LMi
Lyn
Aur
Per
And
Gem
Tri
Cnc
Mars
Ari
Leo
Vesta
Path of Moon
Ori
Flora
Ecliptic
Tau
Vir
Sun
CMi
Psc
Sex
Comet Harrington
Mon
Pallas
Crt
Hya
Eri
Cet
Crv
CMa
Lep
For
Sc
Col
Cae
Pup
Phe

Comet Borrelly brightens in the morning sky

Asteroid Massalia is at opposition on September 19

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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1
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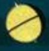
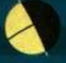
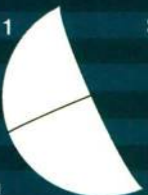
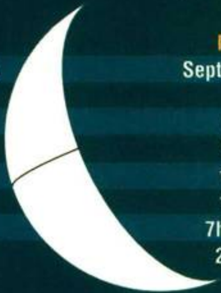
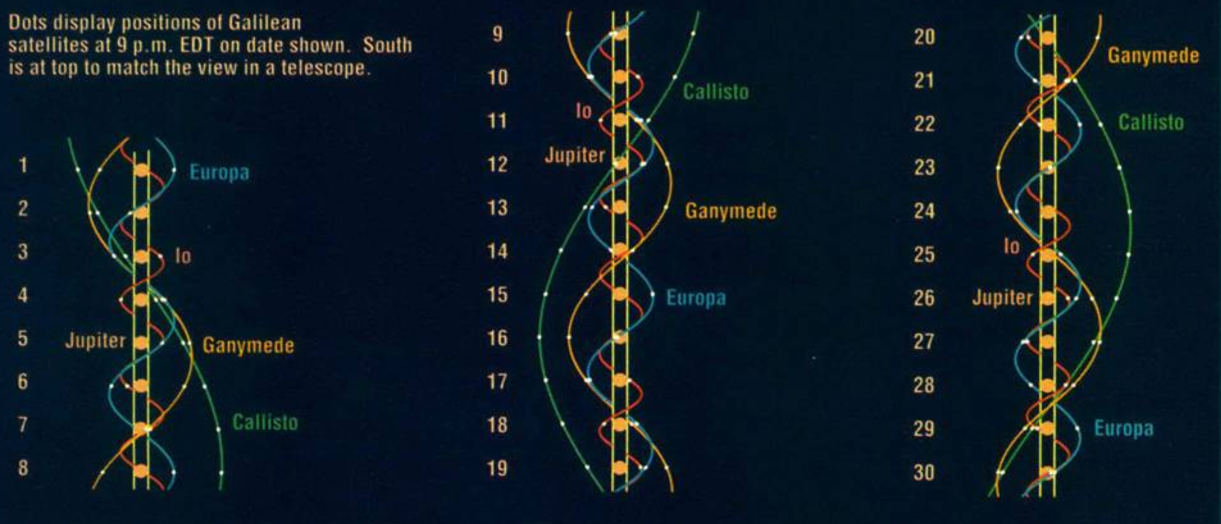
23
22
21

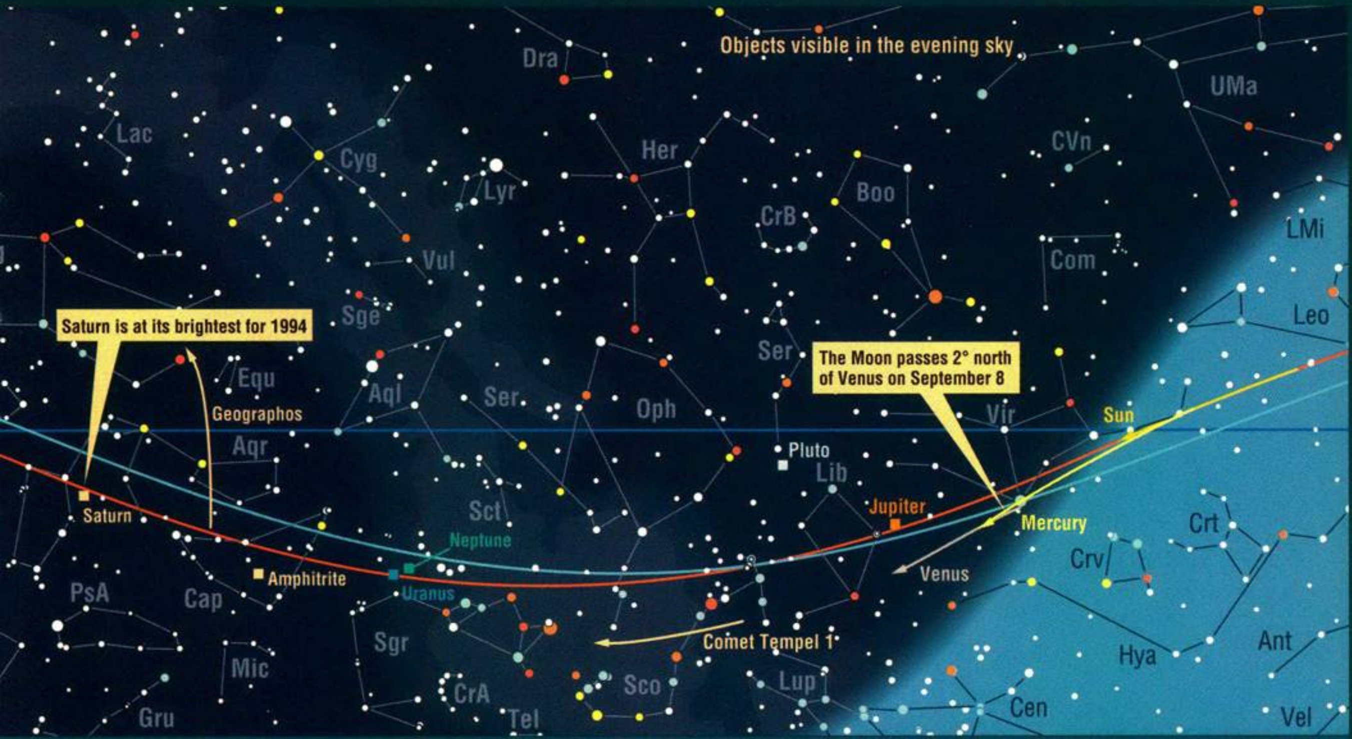
PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	September 1	September 30	September 1	September 30	September 15
Magnitude	−0.4	0.2	−4.4	−4.6	1.1
Angular Size	5.2"	7.3"	26.6"	40.6"	5.6"
Illumination	88%	53%	45%	25%	90%
Distance (AU) from Earth	1.298	0.928	0.627	0.411	1.682
Distance (AU) from Sun	0.438	0.438	0.728	0.727	1.526
Right Ascension (2000.0)	11h42.3m	13h56.3m	13h25.5m	14h42.4m	7h20.7m
Declination (2000.0)	2°28'	−15°13'	−11°55'	−22°04'	22°48'

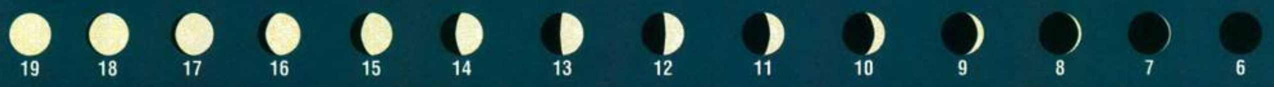
JUPITER'S MOONS

Dots display positions of Galilean satellites at 9 p.m. EDT on date shown. South is at top to match the view in a telescope.




Objects visible in the evening sky
Dra
UMa
Lac
Cyg
Lyr
Her
CVn
CrB
Boo
LMi
Vul
Com
Sge
Leo
Saturn is at its brightest for 1994
Equ
Ser
The Moon passes 2° north of Venus on September 8
Aql
Ser
Oph
Vir
Geographos
Sun
Aqr
Pluto
Lib
Jupiter
Saturn
Sct
Mercury
Crt
Neptune
Venus
Crv
Amphitrite
Uranus
PsA
Cap
Sgr
Comet Tempel 1
Ant
Hya
Mic
CrA
Sco
Lup
Cen
Gru
Tel
Vel

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.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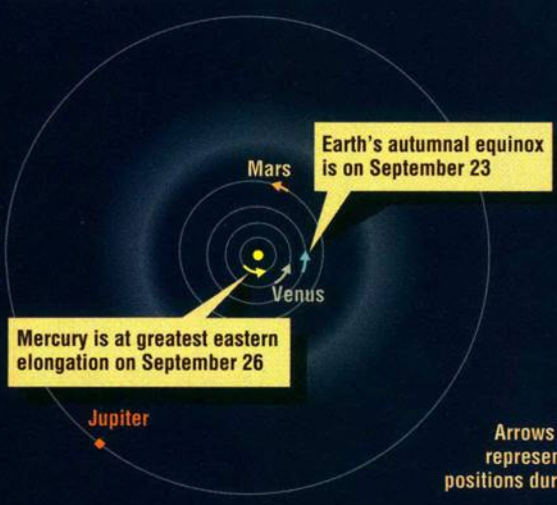
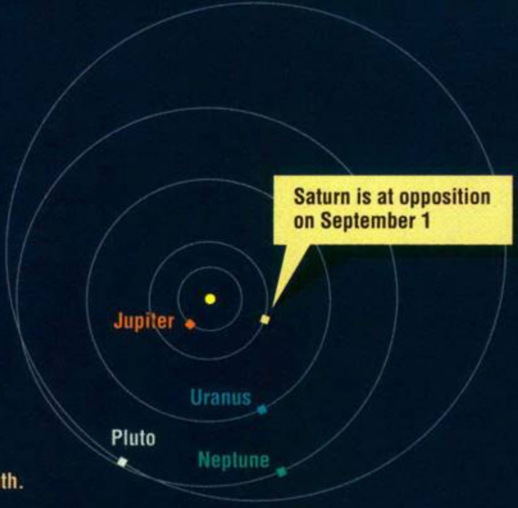
JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
September 15	September 15	September 15	September 15	September 15
−1.8	0.5	5.7	7.9	13.8
32.9"	19.0"	3.7"	2.3"	0.1"
99%	100%	100%	100%	100%
5.994	8.733	19.144	29.680	30.215
5.405	9.711	19.674	30.176	29.798
14h40.1m	22h41.9m	19h37.9m	19h29.3m	15h46.7m
−14°38'	−10°23'	−22°04'	−21°15'	−5°59'

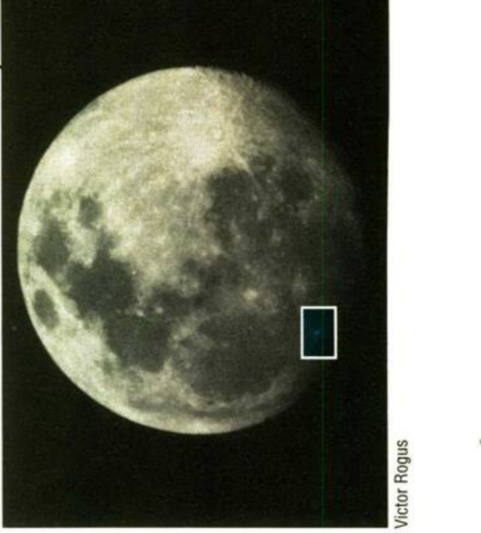
THE PLANETS IN THEIR ORBITS


Mars
Earth's autumnal equinox is on September 23
Venus
Mercury is at greatest eastern elongation on September 26
Jupiter

Arrows and dots represent planets' positions during the month.


Saturn is at opposition on September 1
Jupiter
Uranus
Pluto
Neptune

PROBING THE ARISTARCHUS AREA



Victor Rogus

A young, bright crater pairs with an ancient river of lava in this geologically diverse region of the Moon.

by Michael T. Kitt

Many casual lunar observers plan their viewing sessions for periods when the Moon is a thin crescent or near First Quarter phase, when our satellite lies conveniently in the evening sky and its subdued glare allows extended viewing through a telescope. But if you observe only at this time, you'll be missing an alluring region in the northwestern part of the Moon that comes into view two or three nights before Full Moon. Then the terminator — the dividing line between sunlight and darkness — passes across the vast expanse of Oceanus Procellarum and grazing sunlight reveals the crater **Aristarchus**, the brightest feature on the Moon.

Judged by its brightness, Aristarchus must be one of the youngest of the larger lunar craters. Brightness equates with youth on the Moon because solar radiation gradually darkens fresh impact ejecta. The impact that formed Aristarchus must have occurred within the last few hundred million years.

Sunrise on Aristarchus confirms the crater's young age by revealing exquisitely defined features, seemingly untouched by the glacially slow process of erosion by micrometeorites. The 40-kilometer-wide crater shows a knife-edge rim and many narrow terraces that step down to the crater's floor. Detail within the crater's bowl becomes difficult to see as the Sun rises higher, however, because Aristarchus reflects so much light in Earth's direction. A polarizing or deep yellow filter will help you see the tiny central peak. Also look for the series of dark bands running vertically down the inner crater wall, caused by landslides that exposed dark bedrock.

Just how bright is Aristarchus? Try looking at the Moon a few days after New Moon. Put the sunlit sliver of the Moon just outside your telescope's field of view and look at the Earthlit portion of the disk. Almost opposite the sunlit crescent, you'll see Aristarchus and the blanket of pulverized rock tossed from the crater during the violent impact that created it.

As sunlight advances across Aristarchus in the days before Full Moon, it reveals a lozenge-shaped hilly area immediately northwest of the crater, known to lunar geologists as the Aristarchus plateau. And snaking its way downhill from the heights of this uplift is **Schröter's Valley**. This valley was first charted in detail by the German selenographer Johann Schröter in the late-18th century.

Schröter's Valley is the largest sinuous rille on the Moon, measuring about 160 km long, up to 11 km wide, and 1 km deep. It originates in an ill-defined oval crater nicknamed the "Cobra's Head." One glance at this formation will convince you that this is one of the most apt nicknames in the annals of astronomy, for Schröter's Valley looks just like a wicked snake poised to snap at the eroded crater **Herodotus** adjacent to and slightly smaller than Aristarchus.

The Cobra's Head is an old volcanic vent that once spewed lava across the Aristarchus plateau and then downhill for over 160 km before emptying onto the plains of Oceanus Procellarum. The valley it created looks like a dry riverbed, but this river flowed with molten rock instead of cool water.

The Aristarchus plateau itself is a vast volcanic formation, as evidenced by the many rilles and domes on its surface. The area's largest dome nestles within the curving arc of Schröter's Valley. Larger telescopes reveal a tiny craterlet atop this dome. The volcanism that gave rise to the domes also formed **Rimae Aristarchus**, the system of eight very fine sinuous rilles that appear directly north of Aristarchus and meander up to 120 km. Spotting these rilles requires grazing sunlight, a moderate-sized telescope, and a bit of perseverance.

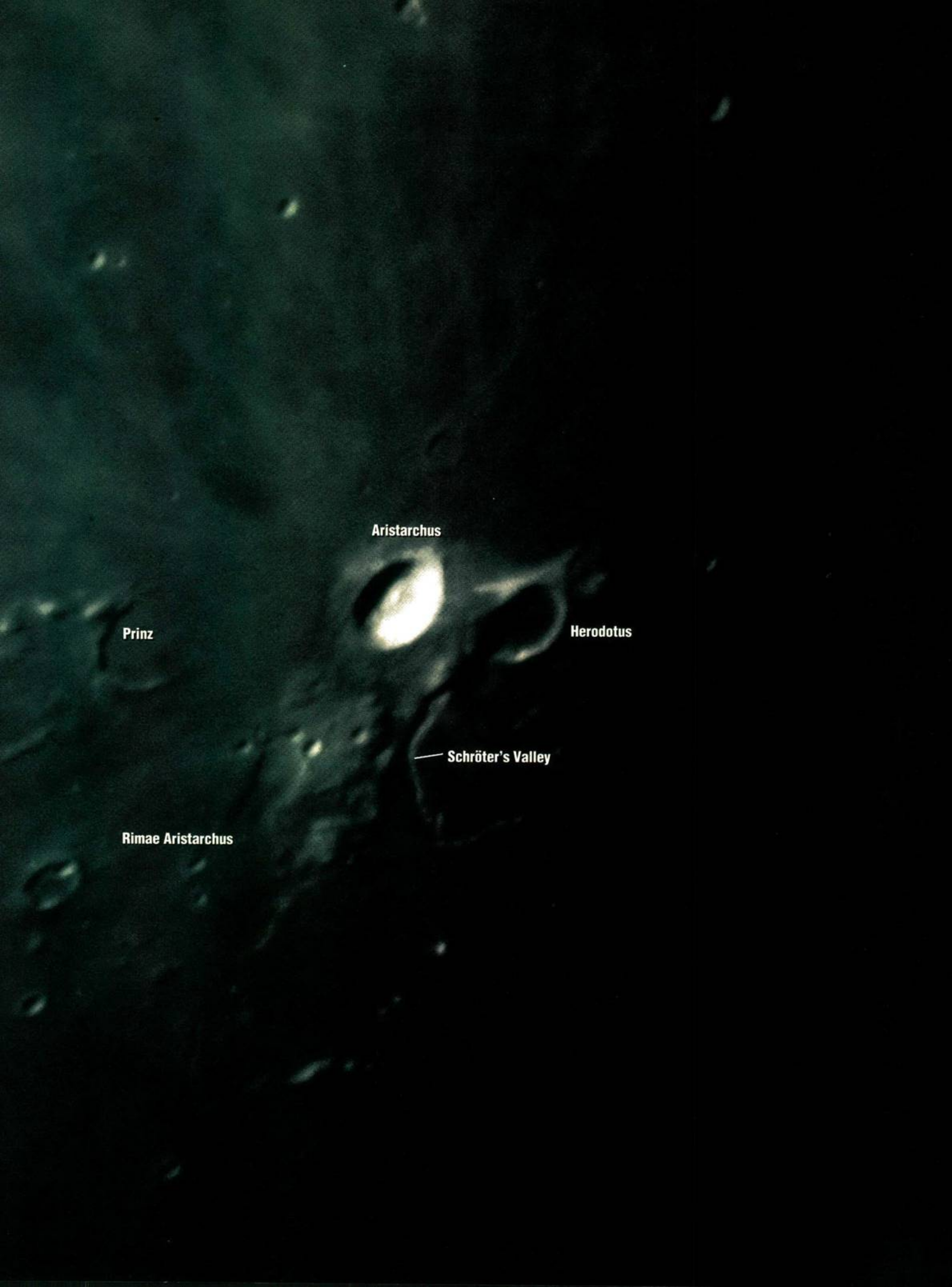
Directly east of the Aristarchus plateau lies the remains of a flooded crater, 47-km-wide **Prinz**. Only half of this crater's rim survived the onslaught of lava from Oceanus Procellarum. Immediately north of Prinz is yet another set of sinuous rilles, even more challenging than the ones on the Aristarchus plateau. Two of the rilles are easier to locate because they originate in fairly distinct, oval-shaped craterlets.

A little farther east lies a group of isolated peaks called Montes Harbinger. They shine brilliantly when the terminator passes across them at local sunrise. These peaks got their name because they serve as harbingers of the coming dawn for Aristarchus and the fabulous area surrounding it. Each lunar month, this pretty formation provides a long-distance alarm clock announcing dawn's imminent arrival on the Aristarchus plateau and Schröter's Valley. Why not use it as a wake-up call to explore this underappreciated region? ☐

BRILLIANT ARISTARCHUS and the sinuous Schröter's Valley stand out boldly a few days before Full Moon.

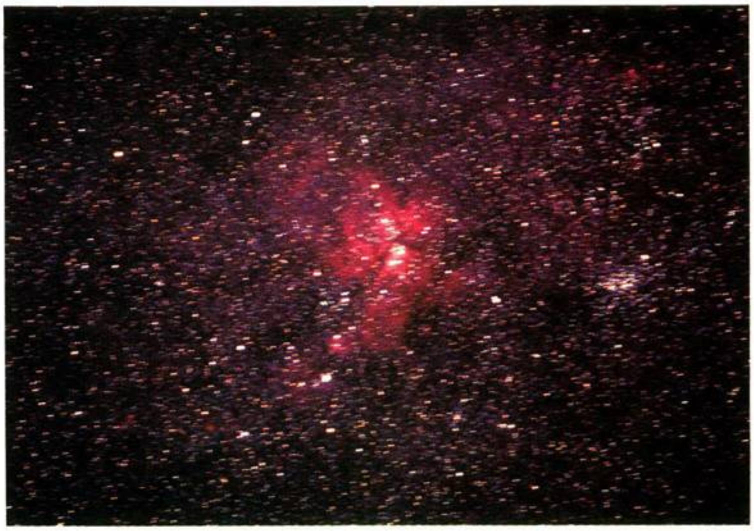
Michael T. Kitt is an experienced lunar observer and author of The Moon: An Observing Guide for Backyard Telescopes *(Kalmbach, 1992).*

Jean Dragesco



Aristarchus
Prinz
Herodotus
Schröter's Valley
Rimae Aristarchus

Beating Back the Guiding Gremlins



From deep inside a telescope's drive to high in the Earth's atmosphere, gremlins are waiting to ambush your astrophotos.

Story and photos by Alan Dyer

Click. Now, where's the star? Ah, there. *Whirr.* OK, it's back. Nope, it's drifting in declination. *Buzzzz.* Uh, oh. Lost sight of it. Whoa! It's over there. *Click, click, click!* Oops, too far. *Click. Click.*

Is this any way to enjoy the night sky? Probably not. Staring at a faint star minute after minute, perhaps hour after hour, while jockeying it around some equally faint crosshairs is, well, tedious. It's hard to imagine anyone who actually enjoys guiding a telescope. But guiding is a necessary ritual for landing deep-sky astrophotos. Yet all that careful work can be torpedoed by a host of hidden problems that could lead to photos with wiggles for stars.

Pitfalls on the road to great astrophotos can lurk in a telescope's rings or mount, even in the sky itself. Is there any way to tame the guiding gremlins? Yes! All it takes is a little preparation and an awareness of where guiding problems lie. One enemy could be hiding in a spot where it's least expected: the telescope drive.

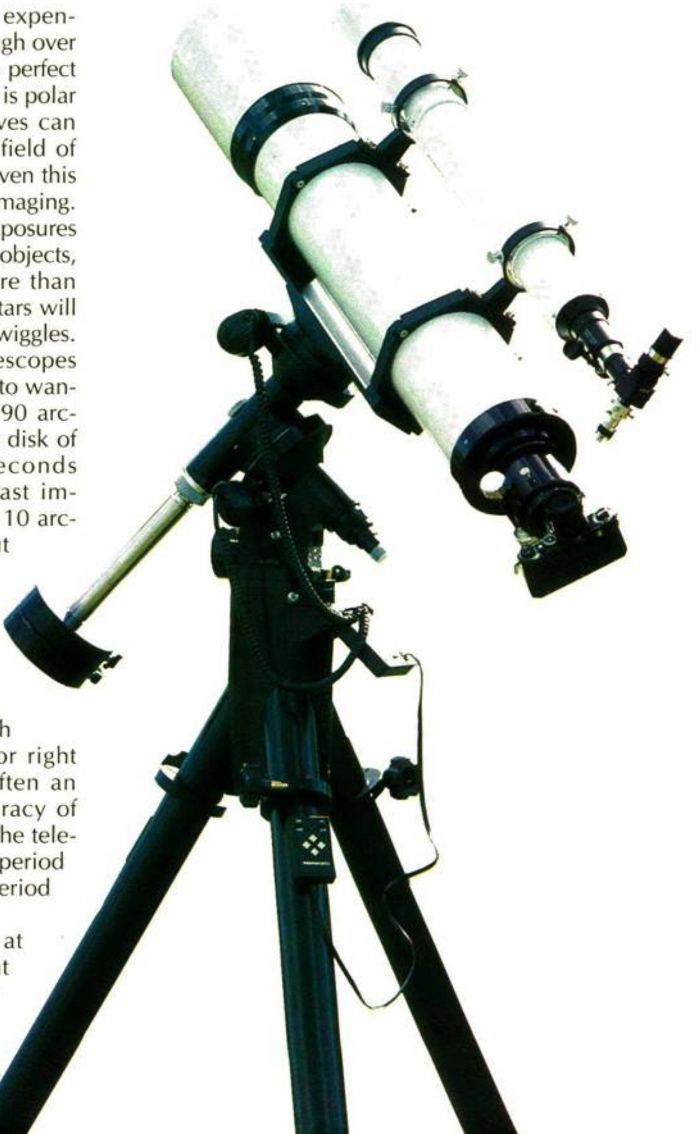
When Problems Start to Mount

It's a hard, cruel fact that no telescope drive, no matter how expensive, can track accurately enough over long periods to render stars as perfect pinpoints. Provided the mount is polar aligned, many of today's drives can keep objects in an eyepiece field of view for hours at a time, but even this is not good enough for astroimaging. During the 5- to 90-minute exposures necessary to capture deep-sky objects, if the image wanders by more than two or three arcseconds, the stars will stretch out into those dreaded wiggles.

On most commercial telescopes it's not unusual for the image to wander back and forth by 30 to 90 arcseconds. (By comparison, the disk of Jupiter is about 40 arcseconds across). The best drives boast improved tracking errors of 5 to 10 arcseconds — much better, but still enough to trail stars if the telescope is left to track unattended.

Tracking error is periodic in nature and shows itself as a regular wandering of the telescope back and forth in the east-west direction, or right ascension. This culprit is often an error in the machining accuracy of the cylindrical worm gear in the telescope's clock drive, and the period of the error is equal to the period of rotation of this gear.

Such a periodic error is at least predictable, a trait that makes periodic error correction (PEC) circuits

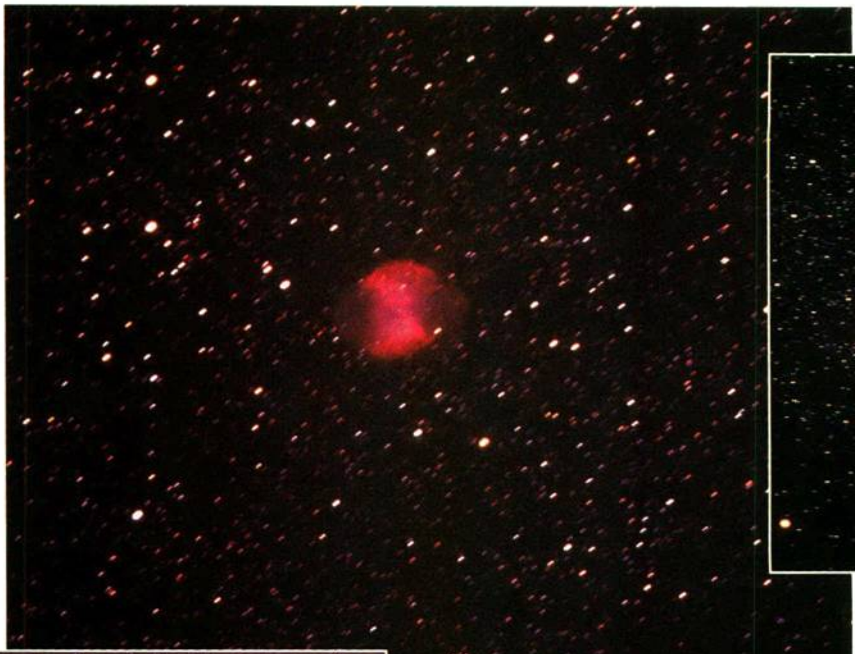


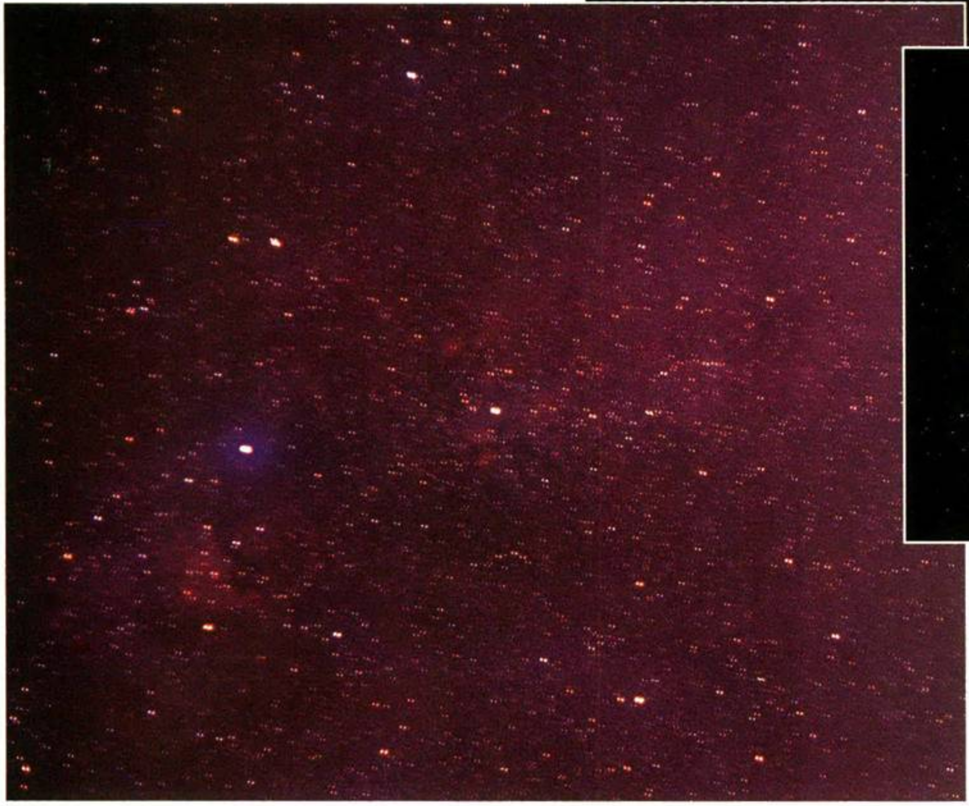
PINPOINT STARS are one of the hallmarks of technical perfection in a deep-sky photograph or CCD image. But when the guiding gremlins win (upper right), stars streak into unsightly trails.

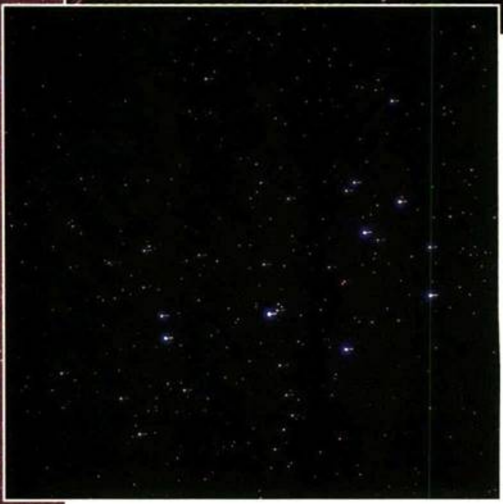
All photos by the author

UNHAPPY TRAILS

POOR POLAR ALIGNMENT — The guide star stayed centered in the crosshairs, but this mount was not precisely polar aligned (right). The camera frame rotated while the guide star (which was off the frame of this photo) remained sharp.







FINGER TROUBLE — Hit the wrong button on the hand controller and the telescope will drive the wrong way (above). Batteries dying in midexposure produce similar cometlike stars.

HITTING THE TELESCOPE — No, it's not a field of identical double stars (above). They're called *foot binaries.* Sometime during the exposure, the telescope was kicked or the guiding eyepiece was bumped by a drowsy astrophotographer. This is a 50mm-lens shot, which should have been goof-proof!

possible. These electronic circuits, integrated into some drive systems, "memorize" any guiding corrections made during one turn of the worm gear (typically a four-minute period) and repeat the correction, over and over again, every four minutes for the rest of the night. PEC is wonderful, but by itself isn't enough. There lurk other errors that can't be predicted, caused by chipped gear teeth, roughness in the bearings, or any number of nagging sources.

On top of errors from the mounting and drive, an astrophotographer must compensate for tracking errors nature creates. As an object moves across the sky, atmospheric refraction will cause it to appear to move more slowly near the horizon than its normal east-to-west speed. The difference depends on the altitude of the target and the temperature of the air. In addition, image wanderings can also be caused by atmospheric turbulence, or "seeing," and by the telescope's being buffeted by the wind.

The final source of tracking error is less-than-perfect polar alignment. Most errors manifest themselves as an east-west motion. But during a long exposure, imprecise polar alignment will cause a north-south drift. Unless astrophotographers use a permanently mounted telescope, polar misalignment will always be a problem.

Proper guiding equipment and

SYSTEM FLEXURE — Despite best efforts, trailed stars persist (above). Something could be shifting in either the guidescope or in the main optics. Here the guidescope's focuser shifted.

technique can help compensate for this and all other sources of improper tracking.

Finding Your Guide Star

Wrestling the guiding gremlins to the ground requires two things: a way of monitoring the position of a star while your camera is taking a picture, and a method of tweaking the telescope's position with arcsecond precision.

To meet the first requirement, astrophotographers turn to either of two solutions. One is to piggyback a small guide telescope onto the main telescope. While the camera looks through the main optics, they look through the guidescope at a star near the target object. The guidescope needn't be large — even a 3-inch refractor works nicely.

The alternative is an off-axis guider that attaches between the camera and telescope focuser. In a Schmidt-Cassegrain, the guider screws onto the back of the telescope. Guiders made for Newtonians slide into the focuser like an eyepiece.

All off-axis guiders contain a small prism at the edge of the light path, just outside the 35mm film frame. This prism picks light from a star off the edge of the field and redirects it into a guiding eyepiece, allowing photography and guiding through the main optics to occur at the same time — no need for a separate guidescope.

Both guiding options require a special eyepiece, one with some type of reticle illuminated by a dim red LED that can be adjusted in brightness. Placing the guide star on the crosshairs can immediately reveal any east-west or north-south wanderings. The best reticle pattern has two sets of parallel lines that cross at right angles in the center of the eyepiece's field of view. The open space at the center of the reticle helps keep the guide star in view at all times.

To complete the guiding system you'll need a speed control for guiding in the east-west — or right ascension — direction, which requires most correction. A telescope equipped with battery-powered DC drive motors meets this need. Most come with a hand controller with push button speed controls as a standard item. The common 2x override speed is fine for guiding.

Those owning a telescope with a drive that runs off of house current (AC) need to add an electronic accessory called a drive corrector. Besides supplying 110-volt AC to the telescope's drive motor, this device can slow down or speed up the motor.

With either type of telescope a fine adjustment in the north-south, or declination, direction is also essential. This can be a manual slow-motion control, provided it is precise and easy to reach when at the guiding eyepiece. A better choice for vibration-free operation is an electric declination motor controlled from the same hand paddle as the RA motions.

Selecting the Right Method

Which of the two guiding methods to use — guidescope or off-axis guider — depends in part on the telescope type. Most Schmidt-Cassegrain owners opt for an off-axis guider because it's accurate, compact, easy to balance, and inexpensive. Besides, bolting a 3-foot-long refractor to the top of a 16-inch-long SCT is a little impractical.

Piggyback guidescopes, however, are the preferred choice of many refractor and Newtonian owners. They offer distinct advantages. For one thing, they make it easier to find a bright guide star. With an off-axis guider, a star has to be within a certain distance and angle of the target. Often a faint guide star has to be used to facilitate comfortable guiding.

But with a guidescope, there's more freedom of movement to pick any star within a degree or so of the target. Guiding can even be done on the target itself, a feature handy for capturing comets moving through the stars.

A guidescope also allows the camera to be framed and focused without affecting the guiding eyepiece: There are no back-and-forth battles between adjusting the camera, acquiring a guide star, readjusting the camera, and so on.

HOW TO SPELL GUIDING RELIEF

S-B-I-G. That stands for Santa Barbara Instrument Group. SBIG's $900 ST-4 autoguider is changing amateur astrophotography. The ST-4 uses a tiny CCD chip to detect movements of a guide star with arcsecond accuracy. If the star drifts, the controller box pulses the appropriate drive motor by the right amount to recenter the star. The ST-4 works with either a guidescope or off-axis guider. On an increasing number of telescopes made today, the ST-4 simply plugs into the same socket the hand controller uses.

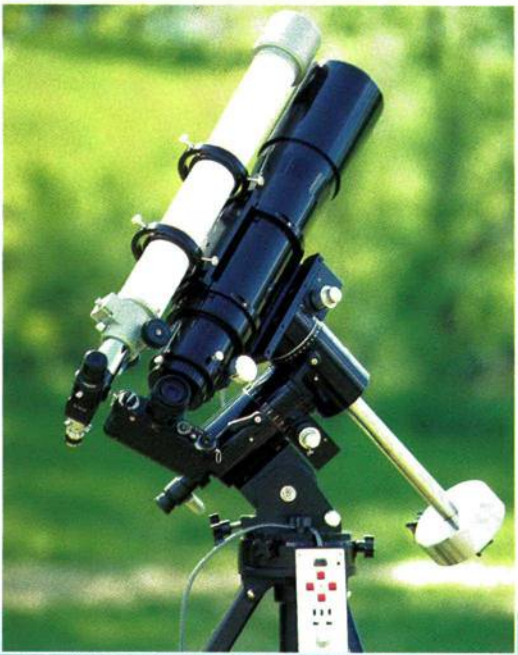
The ST-4 works best on telescopes equipped with motors on both the RA and declination axes. As an autoguider, it cannot deal with large periodic or random errors that move the guide star rapidly off target. An ST-4 is not a solution to a poor drive; it's the final touch of perfection to a good drive.

It does take some experimentation to get all the ST-4's settings right for a given telescope, but once that's done the ST-4 works extremely well. A 2-hour exposure? No problem!

Well, maybe one . . . what to do with all the new-found spare time under the stars? There's a hidden expense involved with buying an ST-4 — another telescope to observe with while the first telescope is taking perfectly guided pictures.

Another advantage to a refractor-style guidescope, at least on a 12-inch or larger Newtonian, is that the guiding eyepiece lies at the lower end of the telescope where it's easily reachable. Consequently, there's no need to spend hours guiding while teetering at the top of a ladder.

A PIGGYBACKED GUIDESCOPE (the white refractor) needs to be securely mounted. And yet it must also be adjustable within its supporting rings so it can swing onto a guide star near the target.



Separate guidescopes are great, but they do have a problem: differential flexure. This causes the guidescope to wiggle one way while the main optics wobble another. Flexure can creep in through flimsy guidescope rings or sagging tubes. In an astrophoto system infected with flexure, errors are introduced by correcting for errors in the guidescope that aren't really occurring in the image. Conversely, errors that cause star trails on the film or CCD might be missed without realizing it.

Newtonian reflectors are especially prone to flexure. Their large tubes are often made of fiberglass or stiffened cardboard, materials that serve as less-than-rigid platforms for add-on guidescopes.

Some flexure-induced errors can be prevented by making sure equipment attach points are secure. Breezes can cause flexure; work behind a windblock or in the lee of a building perhaps. To avoid flexure gremlins completely, some Newtonian owners prefer off-axis guiders. Because guiding and photography are done through the same optics, any image movement that will trail stars on a final photo will also show up as a guide star motion.

AN OFF-AXIS GUIDER (in the middle of the stack) screws directly onto the back of a Schmidt-Cassegrain or onto a focal reducer (the component at left). A camera T-ring (to the right) then attaches to the guider body.

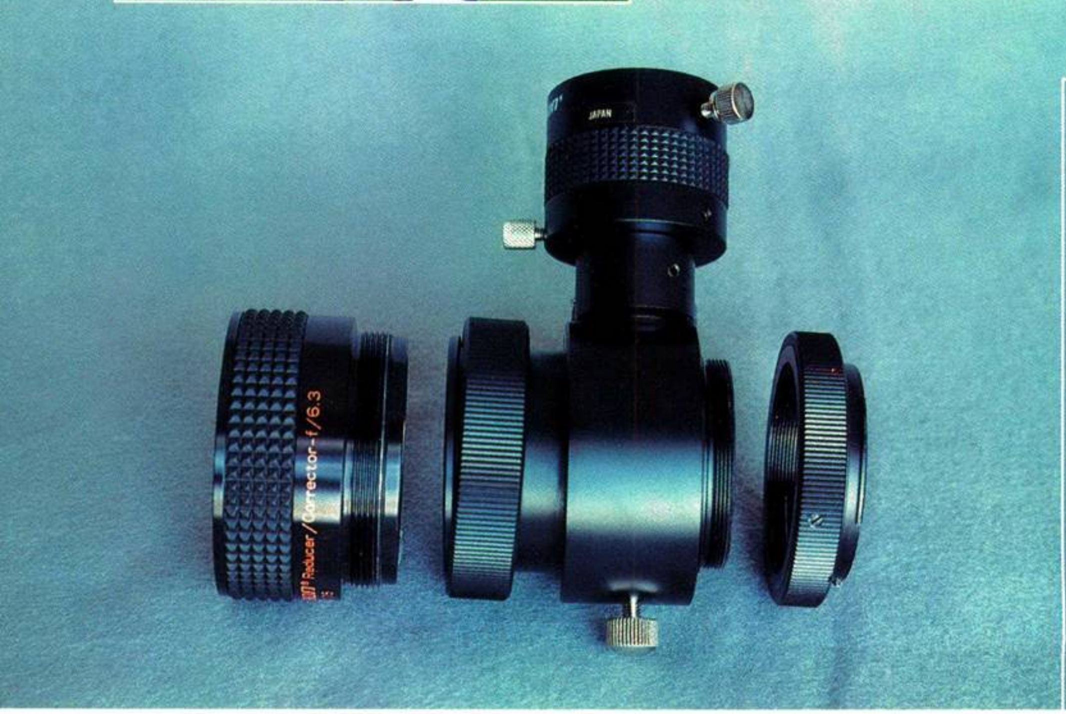
While Newtonian owners can go either route, most owners of photographic refractors prefer the advantages of a separate guidescope. With the smaller, more rigid tubes of most refractors, flexure isn't as prevalent as it is in reflector setups.

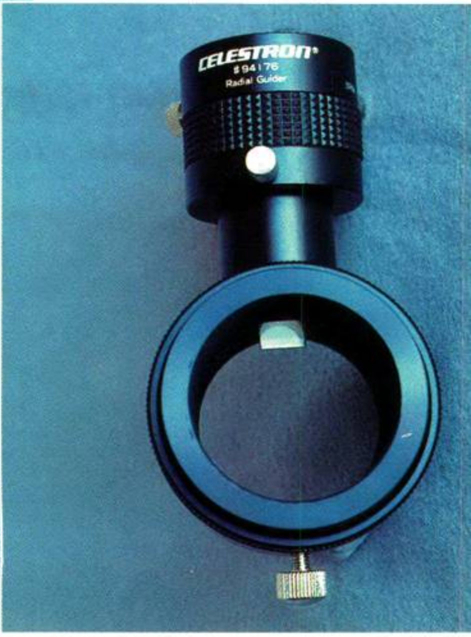
More Gremlin Fighting Tips

Before embarking on a deep-sky imaging session, check out just how accurate guiding needs to be. Aim the telescope at a star near the celestial equator and place the star on the guiding eyepiece's crosshairs. Now turn off the drive for 10 seconds and watch how far the star drifts. That's how far the star can drift from the crosshairs when photographing with a piggybacked 50mm lens and still remain acceptably round on film. It's a pretty generous tolerance. There may be no need to guide at all.

With a 200mm telephoto lens, the tolerance becomes how far the star drifts in three seconds with the drive turned off. Casual guiding may be all that's required. With a 600mm telephoto or short-focal-length telescope, the drift time is one second. With a telescope of longer focal length, the star cannot drift any more than it would in a fraction of a second with the drive off. Chances are that the level of tolerance amounts to no more than a crosshair width, which would keep most people glued to the guiding eyepiece!

This "zero tolerance" applies equally to film and to





MANY BEGINNERS ASSUME the longer the focal length, the better the picture. But shooting with *short* focal lengths beats off the guiding gremlins. For example, a 4-inch refractor with a focal length of only 450mm captured the Eta Carinae Nebula.

CCD cameras. CCDs pick up and record even the slightest movement of star images across their light-sensitive arrays, a property exploited in CCD autoguiders. With the short exposures of CCD cameras, guiding need not be as long, but it still has to be accurate.

To ensure that accuracy with film or CCD, here are some more tips for fighting off the guiding gremlins:

Pour on the power. High power at the guiding eyepiece makes it easier to see guide star excursions. A rule of thumb is that the guiding power should be at least twice the focal length of the image-taking telescope in inches. Guiding an 80-inch-focal-length Schmidt-Cassegrain requires at least 160x. Many photographers bump up their guiding power to four or five times the focal length. Coupling a guiding eyepiece to a Barlow lens is the best way to gain that extra guiding power.

THE PICK-OFF PRISM in an off-axis guider lies just outside the area of a 35mm film frame. The prism deflects the light of a guide star into an illuminated guiding eyepiece (not shown) that inserts into the top of the guider.

Short is beautiful. It's best to avoid shooting with long focal lengths. While a 2,500mm focal length telescope sounds great for shots of small galaxies, what's gained in image scale is lost in perpetually trailed images. Schmidt-Cassegrain owners, for example, can use a telecompressor to effectively shorten the focal length of their telescopes, with the added bonus of shorter exposure times.

Get the bends out. Tighten all loose components, replace a sloppy focuser, upgrade a sagging fiberglass tube with a rigid metal one, and make sure piggybacked cameras are securely fastened and won't slip at the points where they attach.

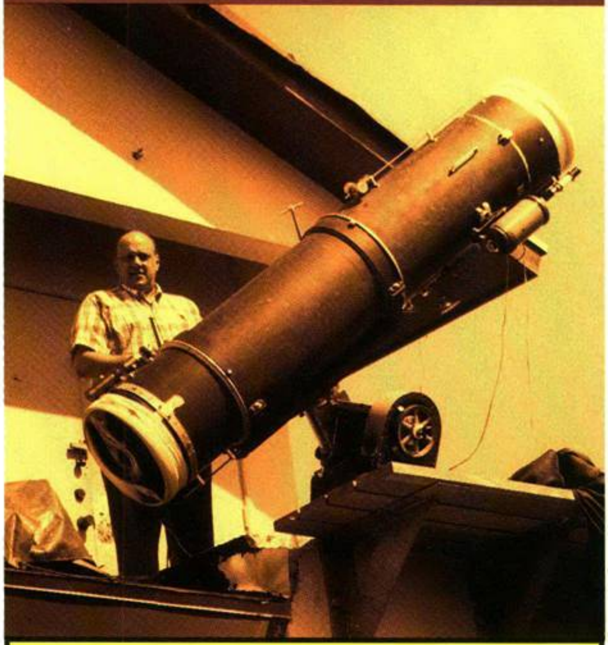
Then after getting set up each night, it's smart to allow the system to track for a while before starting the first exposure. This will let the telescope and mount "settle in."

Getting the gears. If a clock drive has large periodic or random errors, the only solution may be a new drive system from a manufacturer of custom-machined telescope drives — or an entirely new mount.

Beating off the guiding gremlins takes patience. But in return for the effort and the lonely stints at the guiding eyepiece, the reward will be images of glowing nebulae and galaxies, elusive objects barely glimpsed through a telescope that the camera magically picks out of the sky. ☐

A former editor at ASTRONOMY, *Alan Dyer now pursues astrophotography under the sometimes-dark, sometimes-aurora-filled skies of southern Alberta.*

Seeing & Believing



Perry W. Remaklus

The Quest for the Ultimate Planetary Image

by Phil Dombrowski

If asked what he does for a living, Don Parker will muscle in real close and whisper, "I pump gas. I'm an anesthesiologist." It doesn't take long to figure out that Donald C. Parker, M.D., is blessed with a sense of humor. Regular readers of ASTRONOMY have probably noticed something else he's blessed with — a knack for taking excellent planet photos. Some rival those taken by professional observatories, even approaching the quality of Voyager or Viking spacecraft images. Developing this knack began in 1973, when Parker settled in Miami as a medical intern. The planetary bug really bit after a 17-year hiatus.

"When my parents threatened to make a bird bath out of the telescope I left with them in Chicago," says Parker, "I figured it was time to bring the thing down here and dabble in observing." The scope hadn't been used much during Parker's run through medical school and subsequent stint in the Navy.

"It was stored in a backyard tarpaper observatory and, according to my parents, had attracted every spider in Illinois. Time to use it or lose it . . . heh, heh." Use it he did. It was then that Parker's other interests — scuba diving and sailing, the main reasons for his moving to south Florida — took a back seat.

Parker soon realized the beauty of stable, ocean air that allows for detailed views of the planets. "Jupiter showed loads of cloud detail, and Mars coming out of opposition was astounding," he recalls. So an interest that had been dormant since childhood was reawakened, and it's been expanding ever since, from drawing planets to producing some of the finest conventional planetary photography and CCD imaging the world has ever seen.

As a child growing up in Chicago, Parker became interested in astronomy because of his mother, who read him books like *Stars for Sam* and Sidgwick's *Observational Astronomy for Amateurs.* He assembled his first telescope at the age of ten with the help of his father. A tree branch supported the stove pipe refractor with a 3-inch objective. As he grew older, Parker's telescopes grew in size.

In the mid-1950s, his Aunt Hattie gave him $100 for Christmas, which he immediately used to buy an 8-inch mirror. He assembled an 8-inch Newtonian with the guidance of Allen J. Thompson's *How to Build a Reflecting Telescope*, and a local machine shop made the mount for a whopping $44. But assembling a telescope wasn't the same as building one from scratch; that involved grinding a mirror. So the young Parker learned to do his share of glass pushing and still uses his homemade 6-inch Newtonian, which was called back into duty after his main 16-inch planetary scope was disassembled for protection from Hurricane Andrew's visit in 1992.

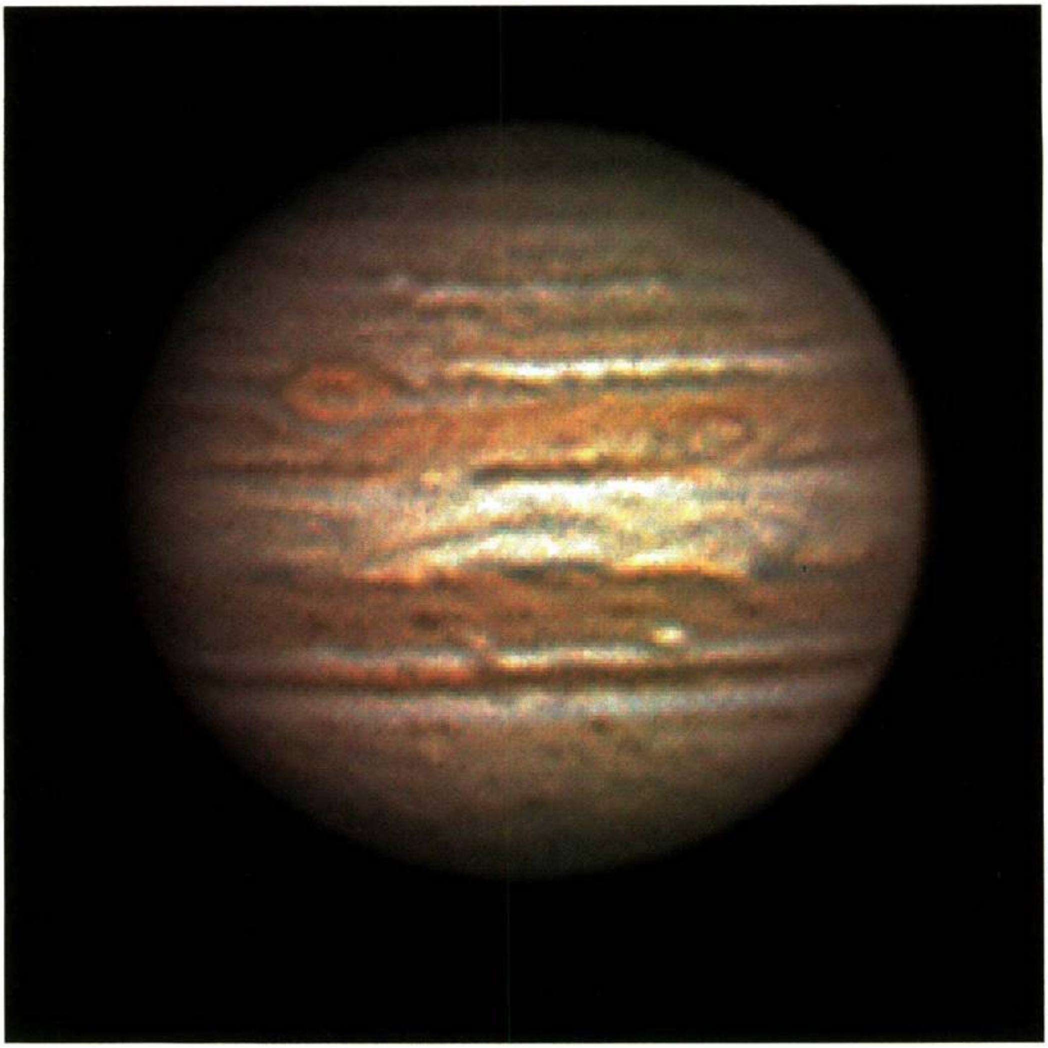
But in 1956 it was the 8-inch that turned him on to Mars. He was always fascinated by the planets and recalls his first views of Jupiter's moons through a "pay-per-view" telescope from the deck of a river boat. In '56, with the 8-inch, he saw broad, fuzzy albedo features on Mars that motivated him to draw and forward his observations to ALPO (the Association of Lunar and Planetary Observers, a group of amateur astronomers that regularly observe and record information about the Sun, Moon, and planets). The thought that Mars might be a place where there was life, coupled with visible changes he could see through the eyepiece, drove Parker to scrutinize the planet with the utmost care. With familiarity comes the unexpected, and Mars had plenty up its sleeve.

During the latter part of its 1956 opposition, a global dust storm engulfed the planet, making it look like a featureless, ruddy ball through the eyepiece.

"In my inexperience, I wrote off the lack of detail to a problem with my scope. It almost frustrated me to the point of swearing off planet observing," says Parker. "Today I'd give my eye teeth to monitor a storm like that!"

Not long after that, Parker made his journey through college, medical school and the Navy. Astronomy, Martian dust storms and all, was relegated to the "things I oughta get around to doing again someday" category.

Parker's first views of Jupiter were through a "pay-per-view" telescope from the deck of a riverboat.



LIKE A GIANT WEATHER MACHINE, Jupiter sports belts, bands, festoons, and the Great Red Spot in this March 10, 1994 image. Jupiter's brown belts are colored by organic chemistry dredged up from far below the main cloud layer.

Planetary images by Don Parker

It was almost two decades after the dust storm of '56 when the 8-inch Newtonian found its way to Miami and Parker's interest in Mars rekindled. A new flow of planetary drawings was routinely forwarded to ALPO. It wasn't long before his work caught the eye of Lowell Observatory astronomer Charles "Chick" Capen, who communicated with Parker and enthusiastically remarked about the quality of the planetary drawings.

"This really floored me. I didn't think I was a great artist. As it turns out, neither did Chick," recalls Parker. "What impressed him the most was what I was drawing, not how well it was drawn."

Which underscores an important point.

"It's discipline and training that makes a great planetary drawing, not artistic skill. I once gave Chick a drawing of Mars that I thought showed nothing but a bunch of streaks. He said, 'You've recovered a feature that's not been seen for years.' My eye was trained to draw detail. His eye was trained to interpret."

As their friendship grew, Capen invited Parker to observe Mars with him at Lowell during its 1977 apparition. Parker recalls what a moving experience it was to see the marvelously detailed planet through the same telescope Percival Lowell used for his historic Mars' studies.

"The image of Mars created by the 24-inch refractor was so bright and intense I thought it was going to burn a hole through my retina," he remembers. "I think Chick thought it was important to share that experience with me, to put our work in perspective."

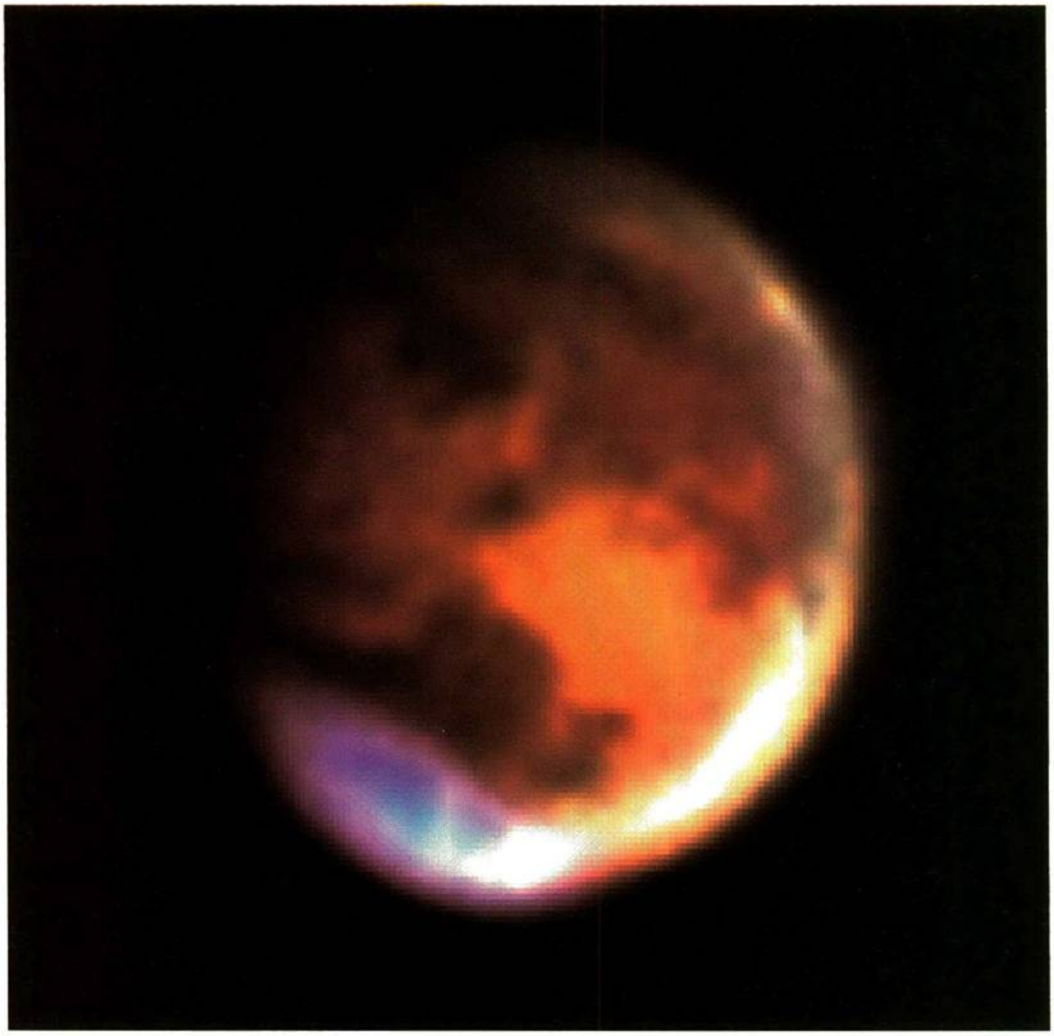
Not long after the Mars Hill experience, Capen encouraged Parker to begin photographing the Red Planet using SO-410 (Tech Pan 2415), an extremely fine-grained, red sensitive black-and-white film. Capen realized that southern Florida's stable seeing would yield exceptional high-resolution pictures. In 1979 Parker began photographing Mars, working from a balcony observatory perched high above the waterway behind his Coral Gables home.

"That was the beauty of our partnership. Chick would have a particular goal in mind when he asked me to try different techniques. It was under his patient guidance that I started planetary photography in earnest," says Parker.

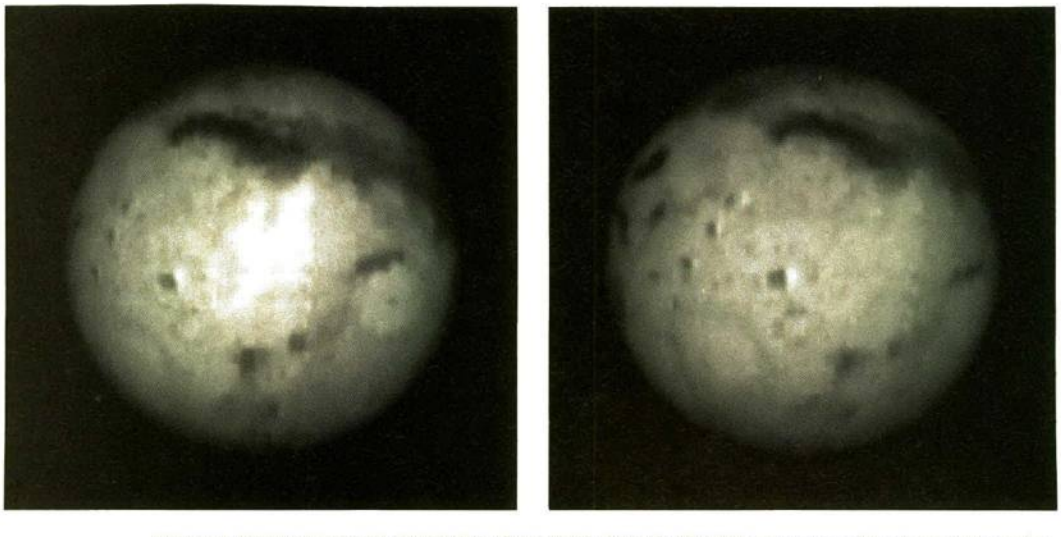
"My parents threatened to make a bird bath out of the telescope I left with them in Chicago."

After Capen's death in 1988, Parker continued his Martian studies, taking color photos with Ektachrome 200 slide film and black-and-white pictures with Tech Pan 2415. Then, in the 1990s, a newer, "sexier" imaging technology arrived on the amateur astronomical scene: CCD cameras.

"I bought a CCD camera in 1992 and it sat in its box for months. I admit, I was intimidated . . . by computer hookups and the like. I kept putting off using it," he recalls. It was only with the help of friend Richard Berry that Parker finally decided to give CCDs a try. Now he's "born again."



AN ICE CAP FORMS under carbon dioxide haze that obscures the Martian north pole each spring. Water ice appears slightly bluer than the surrounding fog. Light brown features are sandy deserts, while the darker albedo markings are rough, rocky areas.



FOUR GIANT VOLCANOS SWING INTO VIEW, arranged in the shape of a triangle, when Mars rotates. Careful scrutiny reveals white clouds forming on each of the mountains' slopes. These clouds, which form early in the afternoon on Mars, are called *orographic clouds*.

"I bought a CCD camera in 1992 and it sat in its box for months. I admit, I was intimidated . . ."

"These cameras can take an image in a fraction of the time it took to get a 5- or 6-second conventional photo of a planet. Plus, there's no darkroom work. I'm saving hundreds of dollars by not using chemistry. My wife loves that part!"

But the CCD's most promising feature is its interface with the computer, where, in the hands of an experienced user, image-processing can pull hidden detail out of an image. In those details lie exciting discoveries, especially unexpected ones.

Fellow Floridian and ALPO Mars Recorder Jeff Beish noticed in one of Parker's CCD images that Mars' North Polar Cap didn't appear under the North Polar Hood, a hazy feature that obscures the cap during the planet's springtime. This discovery was made because Parker accidentally omitted using an infrared rejection filter for the red light portion of his tri-color images.

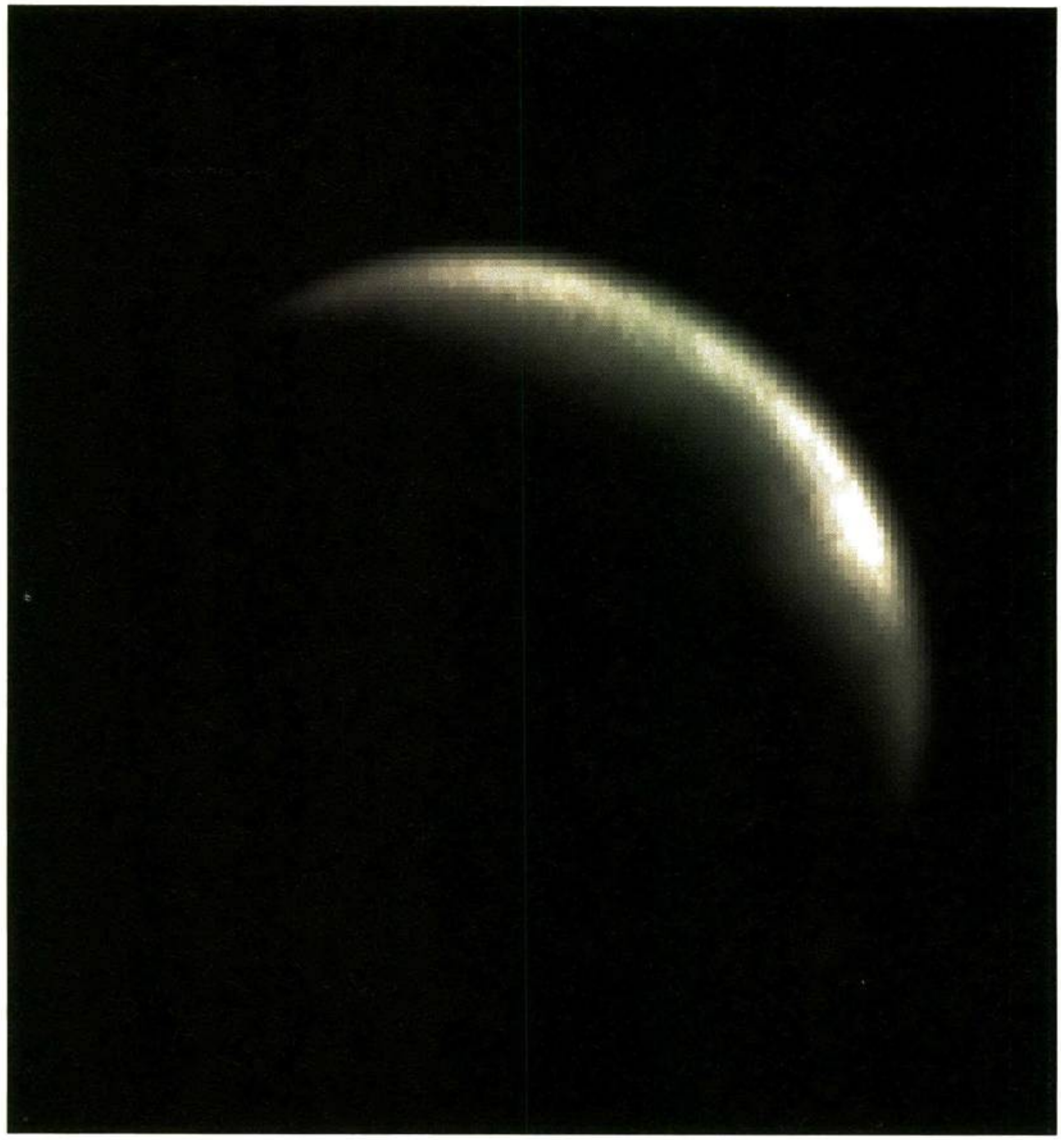
"CCDs are notoriously sensitive to infrared light, so there's this filter I have to screw in whenever I want to take a red photo," says Parker. "If the planet is higher than 45 degrees, I have to climb a step ladder to get to the camera." That night Mars was high, and the air was hot and sticky. He didn't feel like climbing the ladder. "So because I was hot and grumpy that night, we discovered there was no ice under the hood."

Some other Martian features gleaned by Parker's CCD camera: morning fog around Olympus Mons (the planet's largest volcano), equatorial clouds, and multitudes of subtle surface detail changes that might be caused by seasonal winds' shifting dust around the planet.

With Venus, Parker has used the ability to stretch a picture through computer processing to gather data on Venus' upper atmosphere by imaging it in ultraviolet light. Pushing his expertise and CCD technology to the limit, he's even resolved surface markings on Jupiter's moon Ganymede and detected Neptune's Great Dark Spot. But these are just diversions from Mars.

In the coming months, through the 1995 opposition, Parker will be helping NASA's Ames Research Center collect data for a geological survey of the Red Planet.

"They sent me six horrendously expensive filters via registered mail. The details that show up on the images taken through these filters will yield important information on the mineral content of Mars' surface," he says.



A CRESCENT VENUS imaged through an ultraviolet filter starts to reveal cloud detail. This is useful in gaining information on the planet's upper atmospheric circulation.

So, poised on the threshold of undertaking deeper forays into planetary observing and imaging, what advice does Parker have to offer to someone just starting? "Get the best optics you can afford and observe as much as possible. Be sure your telescope is a convenient size so you can use it easily every clear night. Your eye needs training, and the more you observe the better you get at spotting fine detail. Send your observations to ALPO no matter how crude you think they are."

His attention to detail, perhaps the result of his medical training, means nothing is overlooked. Parker sometimes checks his collimation twice a night to ensure that his 16-inch scope (equipped with three 12-volt fans blowing air up the tube) is working at peak performance.

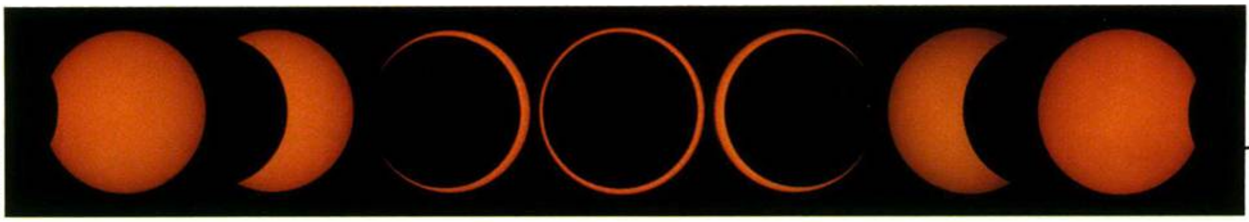
Certainly the south Florida skies have a lot to do with his success, but Parker says seeing should not be a cop-out for amateurs in areas of the world that don't favor planetary observing. "You can get good seeing anywhere, as long as you are patient," he adds.

When asked how he would like to be recognized by his peers, Parker pauses and then comments, "I am an intellectually honest man who seeks the truth in the science that I do. I want to be recognized for a good sense of humor and for having real fun with what I'm doing. If I'm satisfied with my work, I'll start slipping. I believe that I can always do better."

"Get the best optics you can afford and observe as much as possible."

For those who have been following Parker's progress over the years, it's hard to believe his photos can get any better, but seeing is believing. As technology has grown, so has Parker's abilities. Sitting in front of a computer screen examining an image of Mars, he wonders aloud, "maybe this change in contrast will make it even better." You've got to believe him. Look for yourself. Here are planetary images that are exquisite. But Don Parker believes the best is yet to come. ☐

Phil Dombrowski is an amateur astronomer specializing in variable star observing, and has written for ASTRONOMY *and* Earth *magazines.*



Vic Winter

Annulus Americanus

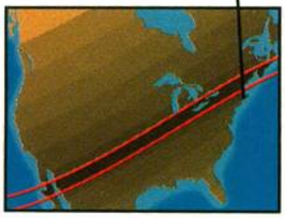
Viewers in and around North America really enjoyed May 10's solar eclipse, their last central eclipse until 2012.

by John Shibley

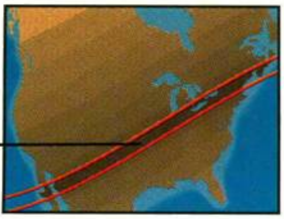
Annulus Americanus . . . America's Ring. As the Moon's shadow cut a swath across America's heartland May 10, thousands of people took advantage of the last opportunity to see a major eclipse from the contiguous United States until 2012. Faced with that reality, some eclipse chasers weren't going to let a minor problem like geography (or weather) get between them and the path of annularity.

Ken Willcox of Bartlesville, Oklahoma, piled into a

Mark Goulet

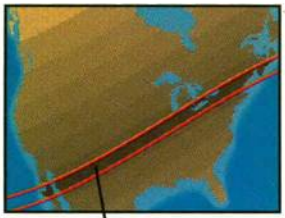


THIS IS NO MOONLIT NIGHT, but a partially eclipsed Sun filtered through cumulus clouds over Seymour, Connecticut.

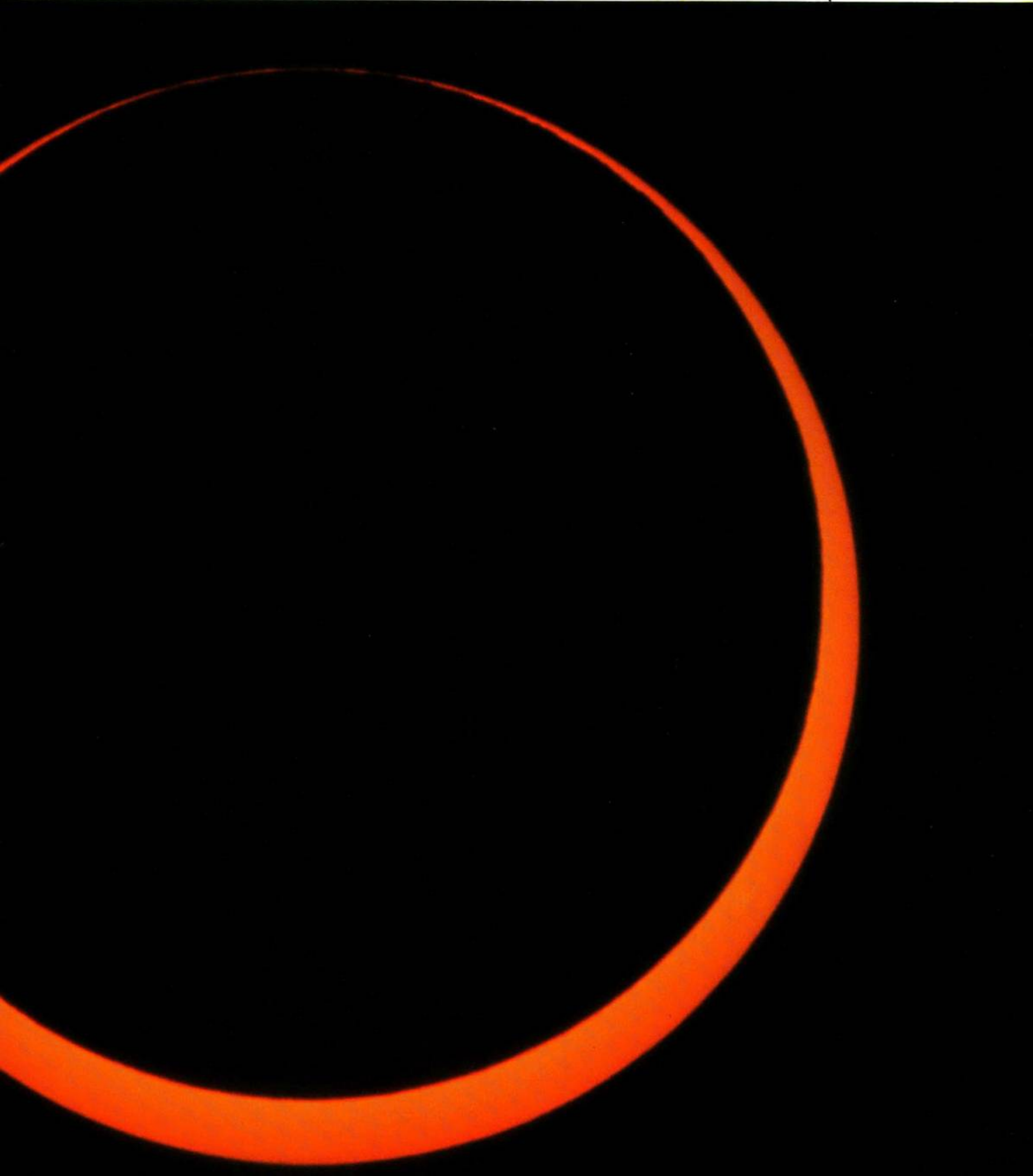


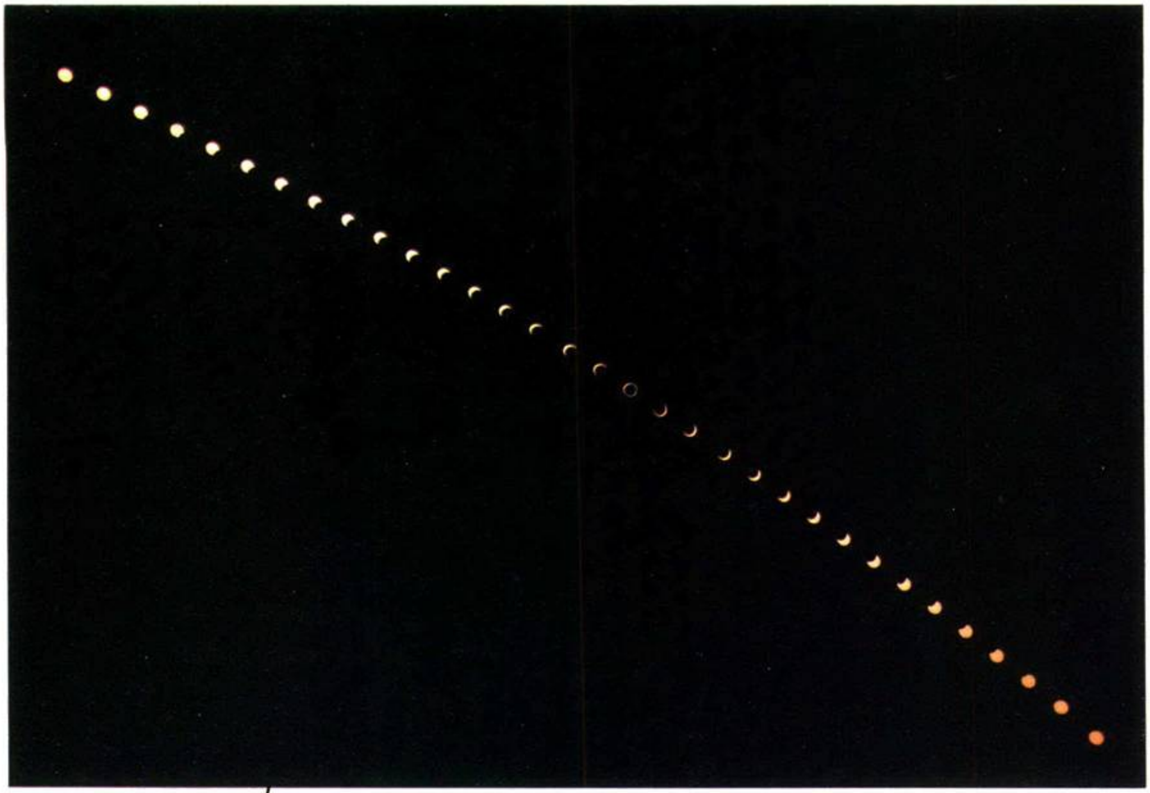
FROM FIRST CONTACT TO FOURTH — seven separate pictures were electronically combined to form this eclipse sequence, as seen from Ft. Scott, Kansas.

SUNLIGHT SHINING through valleys near the Moon's south pole created tiny spots of light called Baily's beads. This photo was taken about 30 miles inside the northern limit of annularity, near Douglas, Arizona.

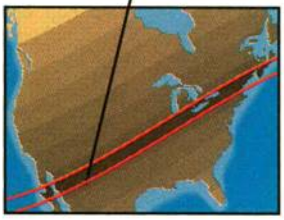


Alan Dyer

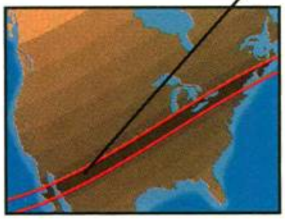




Dan Schechter



KEEPING ITS APPOINTMENT with the Sun (above), the Moon slowly progresses across the face of the Sun as seen from Canutillo, Texas.



LUNAR MOUNTAINS APPEAR IN PROFILE against the Sun's disk in this photo shot on the northern limit of annularity from Deming, New Mexico.

small airplane with friends Danial Johnson, Rick Boswell, and John Geibel and flew to Emporia, Kansas, which lay on the eclipse's northern limit. The 180-mile flight put them into clear skies. "I only had to carry my equipment 50 yards to set up," recalls Willcox. "It was a real hoot!"

After setting up his scope at the base of an airport beacon, Willcox used an 8mm video camera to record Baily's beads along the Moon's eastern limb. (Bailey's Beads are caused by sunlight shining through lunar valleys.) After the eclipse, Johnson and Willcox sent the tapes to a Tulsa television station, which showed the footage on its evening news.

The quest for Baily's beads turned into a science project for Brad Timerson's high school science class from Newark, New York. According to Timerson, the skies over Newark were sunny, but as the expedition drove farther south toward the eclipse's southern limit, in rolled the clouds. The group considered turning back, but after a vote decided to press on.

"While setting up, we even experienced some light showers," he says. But at the appointed time, skies cleared for some great viewing. Three student teams obtained careful timings of Baily's beads.

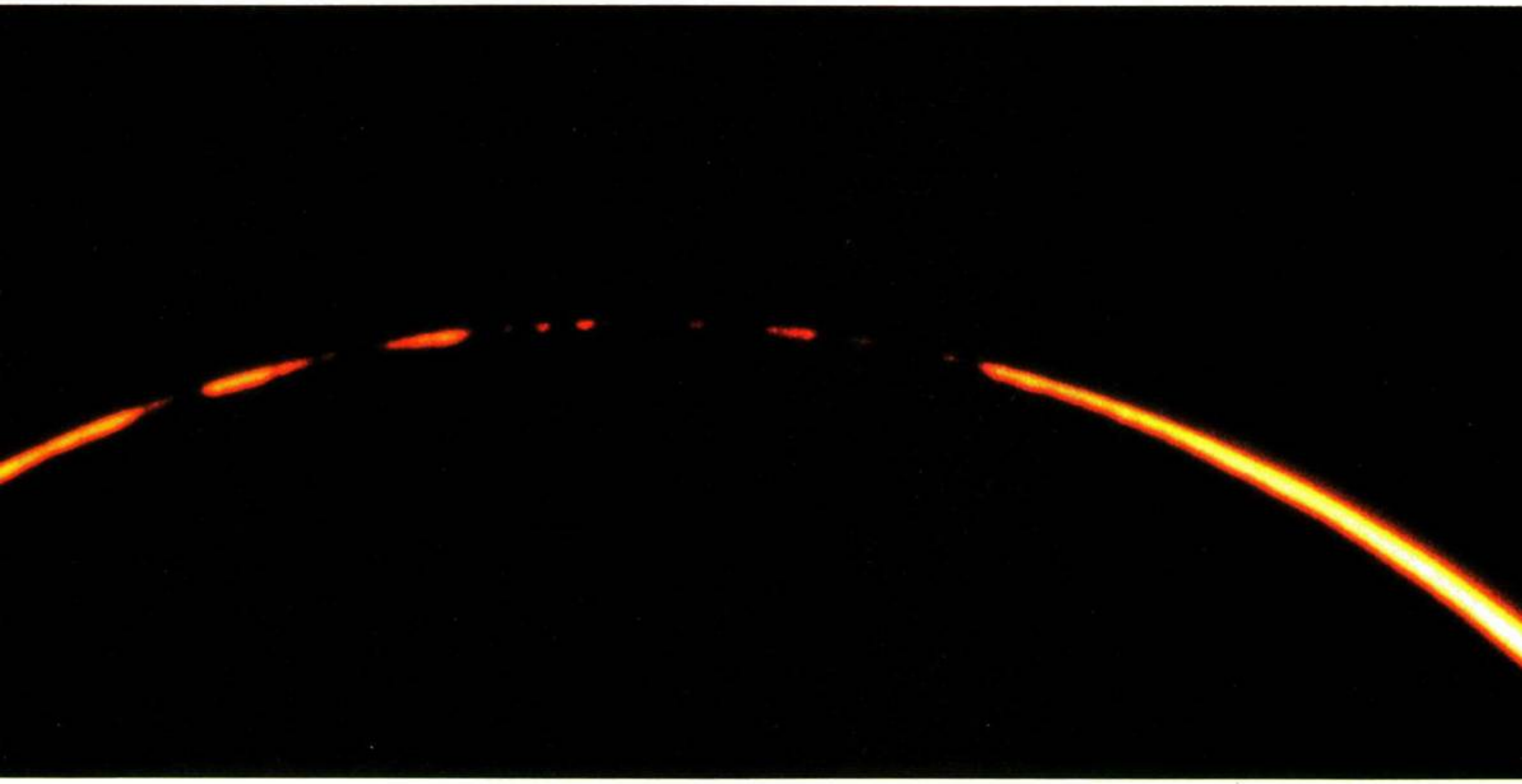
Members of the North Shore Amateur Astronomy Club from Rowley, Massachusetts, also took to the road, this time to view from the centerline in Nobleboro, Maine. Ric Shanahan writes that they were particularly impressed with the Moon's jagged limb. During the entire eclipse, clouds darted in front of the Sun, causing some viewers to joke about "still another totality." But the clouds created a visual treat at midannularity.

"I looked up to see the ring, dimmed to a safe brightness, surrounded by the most surrealistic colors imaginable," says Shanahan. Light streaming through the clouds was causing an iridescent "mother-of-pearl" effect, adding to the already awesome beauty of a solar annulus. The group continued their photographic record of lunar mountains silhouetted against the Sun's disk right up until fourth contact, when Luna's lumbering shadow finally vacated the solar disk.

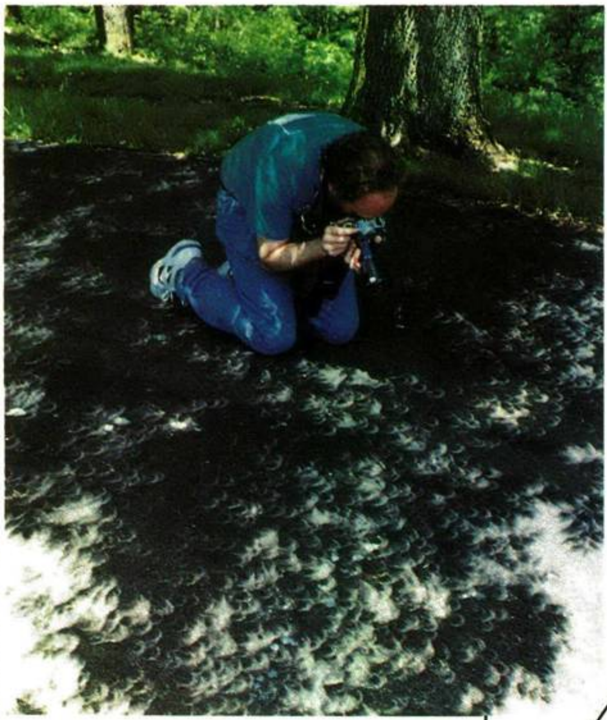
While some observers wanted to photograph eclipse phenomena like Baily's beads, others just wanted to enjoy the spectacle in its purest form. Unfettered by the shackles of timing and photography, they made some interesting observations or just plain had fun.

From the Adirondack Mountains of upstate New York, Patrick Di Justo noticed the eclipsed Sun created a peculiar dimness similar to the transition between night and day. "Every color looked saturated . . . the trees were a deep green, the kind of green you only see in a crayon box."

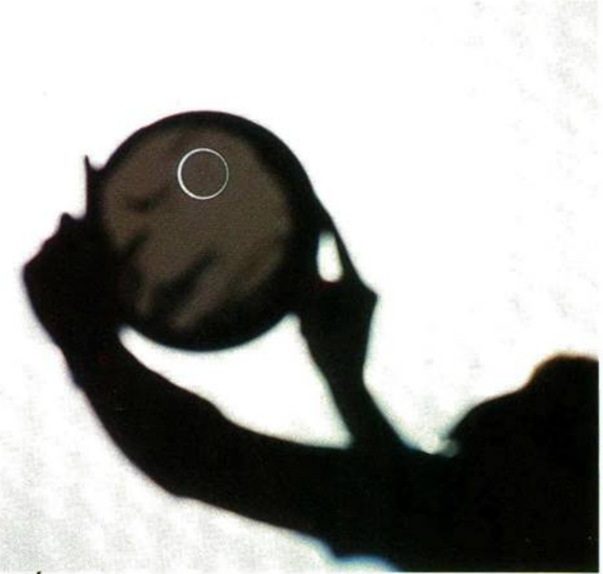
Members of the Chappaqua and Erie Astronomical Society arranged for public observing in North East, Pennsylvania. Before the eclipse was well underway, the club had run out of eclipse eyeshades, so members passed out hastily fabricated pinhole projection cards. When midannularity arrived, "hundreds of spectators in lawn chairs cheered and fire sirens sounded," says CEAS



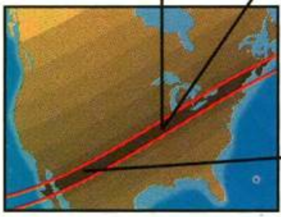
Robert Stephens



ASTRONOMY: John Shibley

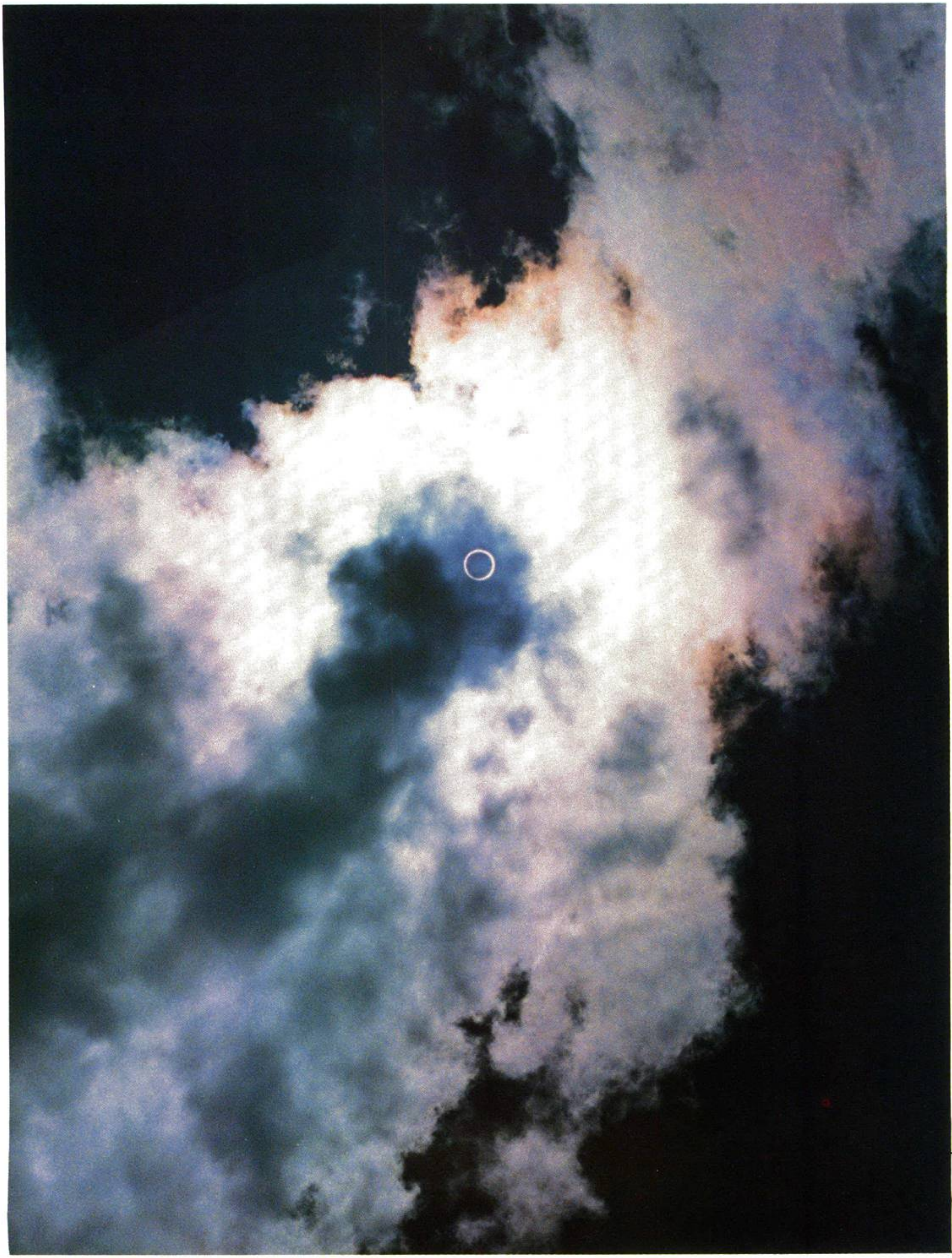


ASTRONOMY: John Shibley

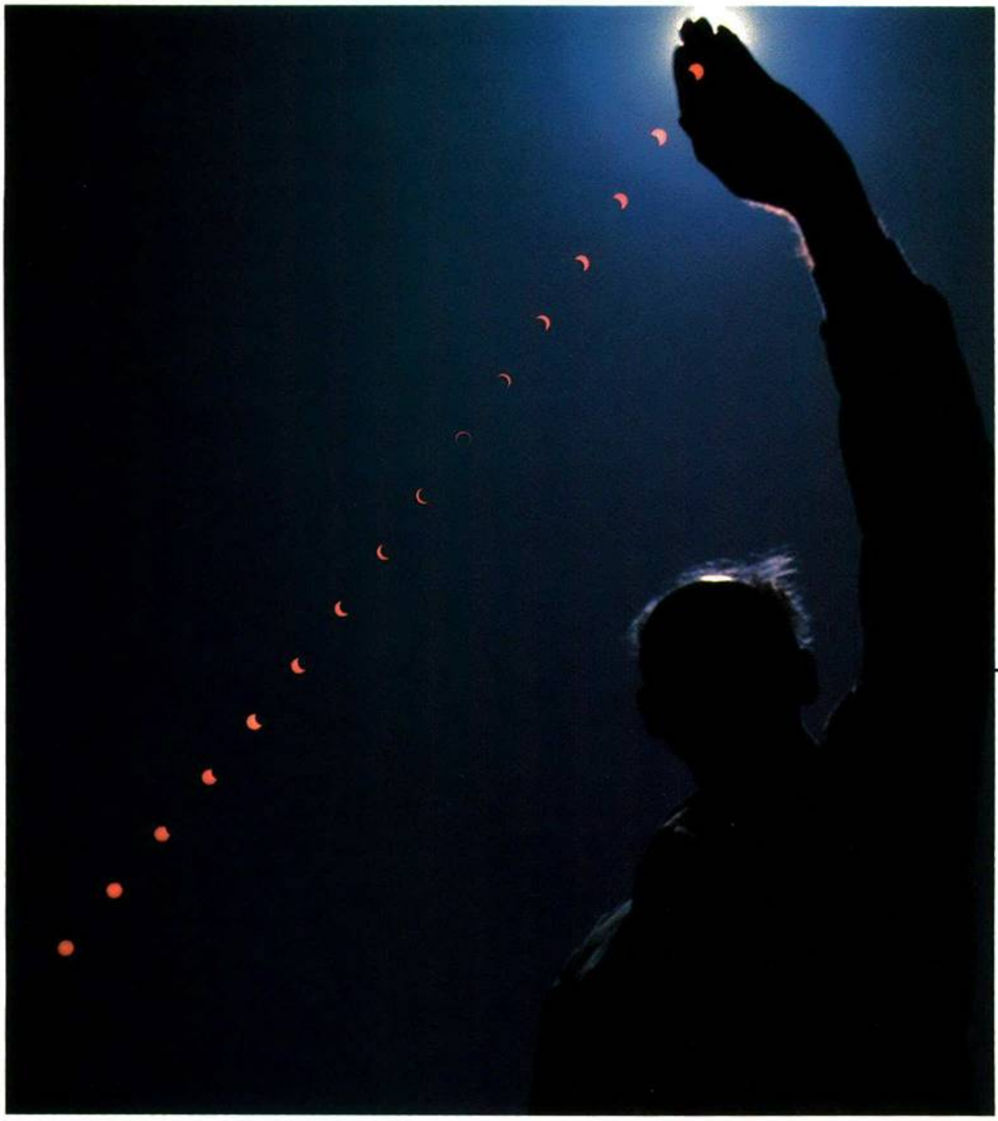


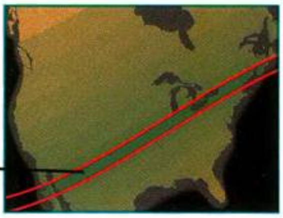
HUNDREDS OF CRESCENTS dot the ground in Springfield, Illinois, around ASTRONOMY's Rich Talcott, who was capturing them on film. The crescents were projected by tiny openings between leaves. Later Talcott observed maximum eclipse using a mylar filter to block out the Sun. In Bisbee, Arizona, Ronald Royer followed the eclipse's progress via eyepiece projection through a telescope.

Ronald Royer



Ric Shanahan





THE MOON'S TRACK ACROSS THE SUN seems to end in the hand of eclipse-chaser Michael Maunder. He was with a tour group from England that observed and photographed the eclipse in Arizona on the Geronimo Trail, near the Mexican border.

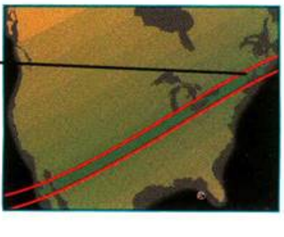
Michael Maunder

member Dan Hatton. A local television station even carried the event live, cutting into its regularly scheduled soap opera to broadcast the eclipse.

Some schoolchildren observing with the CEAS hatched a clever method to measure the Sun's intensity during the eclipse. At first contact, it took only 20 seconds to ignite tissue paper using a magnifying glass. By mideclipse, the paper lasted 90 seconds.

Chicago's David Johnson proved you didn't have to be within the zone of maximum eclipse to enjoy the show. Chicago was just 14 miles north of the annular eclipse's northernmost limit, but from his site at the Adler Planetarium, the Sun was still better than 92 percent covered. He noticed that the air temperature dropped from pre-eclipse seventies to a low of 53 during maximum coverage. He mentions that people at the planetarium measured sunlight intensity during greatest eclipse as being less than 30 percent that of the uneclipsed Sun.

NATURE'S PERFECT FILTER, a fair-weather cumulus cloud, allows enough light through for a look at annularity from Nobleboro, Maine. Note how cloud details appear distinct in the upper right portion of the picture; diffraction also creates some color.



America's Ring? Well the Moon's deepest shadow did skirt through parts of southern Canada. Canadian amateur Dave Chapman rode herd over a group of 150 schoolchildren who viewed annularity through mylar eclipse glasses from a Halifax, Novia Scotia, school yard. At the moment of maximum eclipse, as the kids were jumping for joy, a woman standing in a neighboring yard berated Chapman for putting the youngsters at risk. "On the radio, they say it's dangerous to look," she chastised, while trying to shield herself from the "deadly" rays.

Judging from the number of letters and photos ASTRONOMY has received, most people chose not to hide from this lunar transit of the Sun. Good thing too — it'll be another 18 years before the United States is treated to such a deep eclipse. That's when the Moon will create annularity in a track that runs from the California-Oregon border to western Texas. In the meantime, diehard eclipse chasers can always follow the Moon's shadow to Peru, the Brazilian rain forest, or Siberia. □

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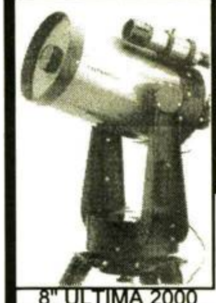

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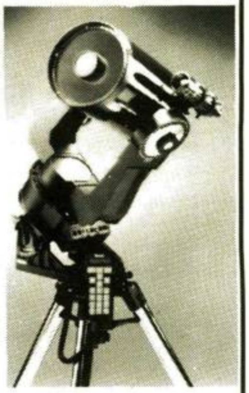

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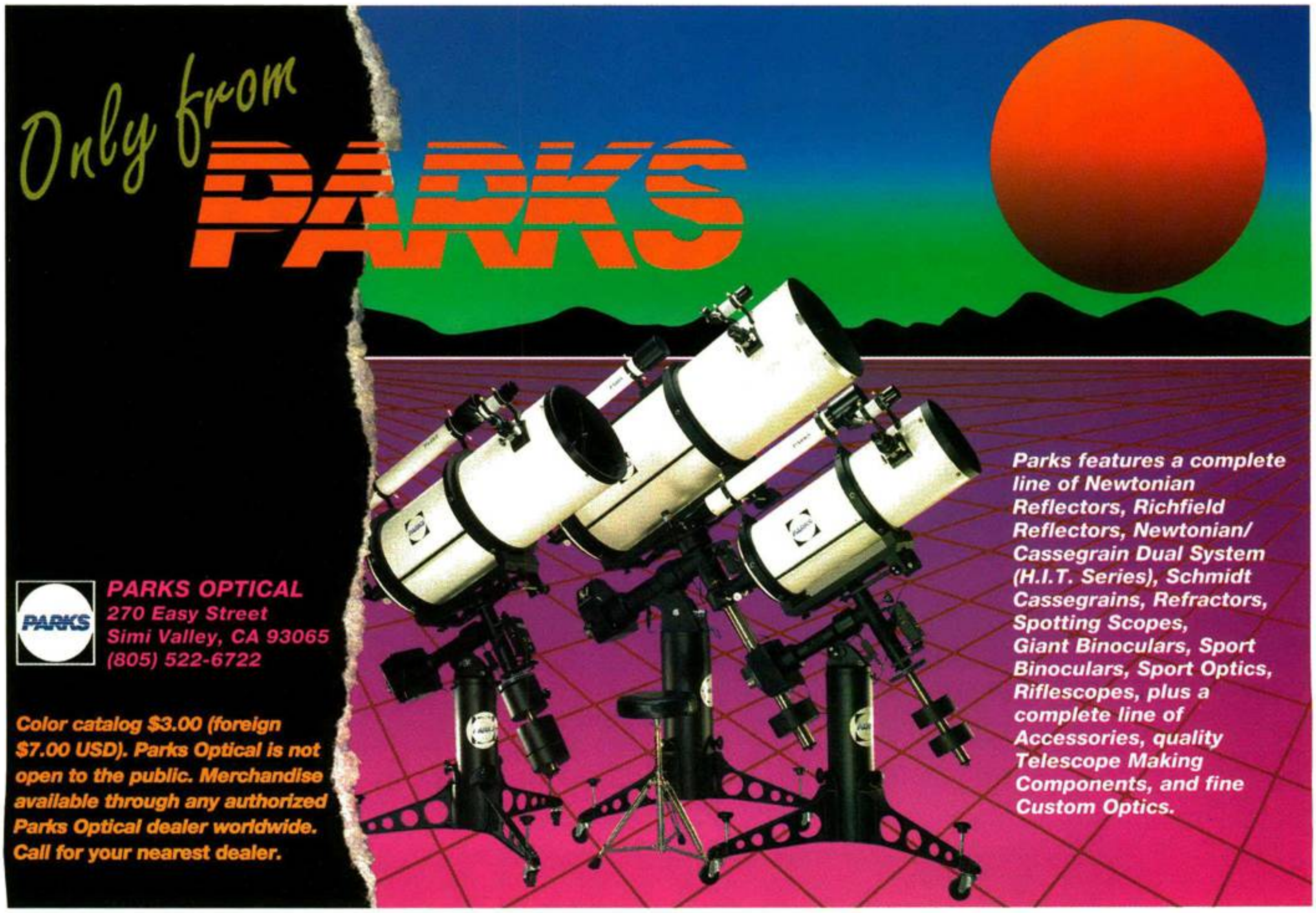

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READER REPORTS

Doug and Wayne's World

"What's that?" said Doug. "I don't know," said Wayne. It was Friday, April 1, 1994, and Doug Millar and Wayne Johnson of the Orange County Astronomers, based near Los Angeles, had just discovered a supernova in the Whirlpool Galaxy, M51. But they didn't know it. They were observing with the 22-inch Khun Telescope at the club's observatory near the town of Anza, California. Jim Leonard, whose CCD camera was attached to the telescope, was taking a nap downstairs to prepare for early morning observing.

The bright star looked distinctly out of place; it glowed at something like 14th magnitude about 14" east and 12" south of the galaxy's nucleus. "We needed to find out if we had a supernova. We had to make sure it wasn't an artifact of the CCD camera," Millar says. So Doug checked the camera and Wayne checked the books. A star clearly appeared in that position in the electronic image. But no star appeared in that position in the books.

Doug and Wayne next called Palomar Observatory to ask for a confirming observation. The astronomers there aimed the mighty 5-meter Hale telescope toward M51 and confirmed the existence of a supernova. Wayne then called other astronomers, letting them know that a supernova had been found in M51. Doug and Wayne then went down and woke up Jim so he could help with the rest of the imaging.

It was a busy night for Doug and Wayne. A new star had appeared in a galaxy far away, shining brilliantly as it exploded and blew its starstuff into the surrounding cosmos.

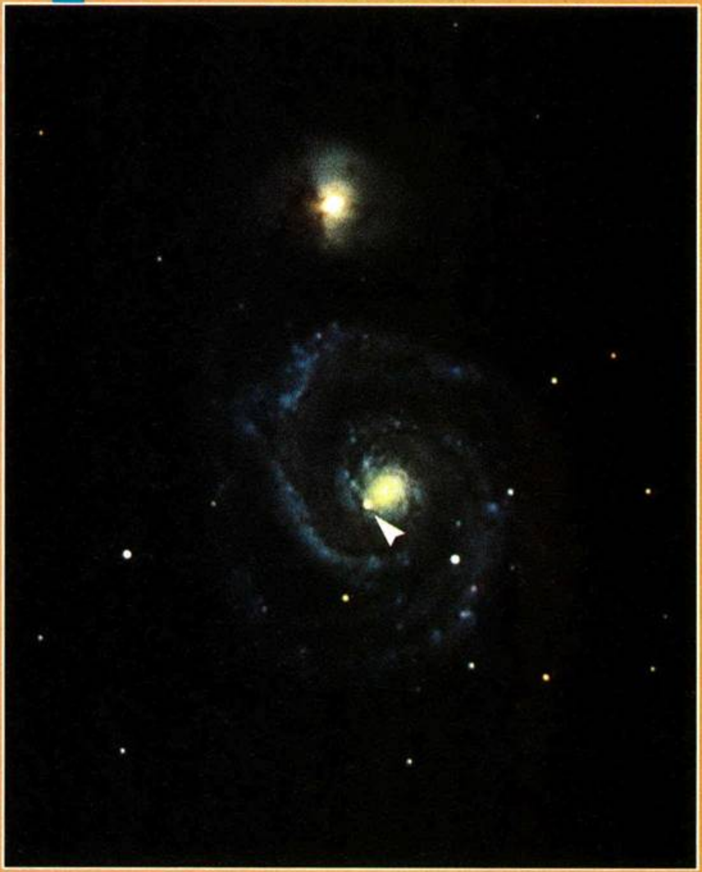
A Curtain of Pink Aurora. "I like to observe the sky in the month of April," says Brenda Culbertson of Harveyville, Kansas. "It's too early for mosquitoes and too late for blizzards." On the 18th Culbertson invited some local astronomy friends to Frog Hollow, the observing site in her back yard. "Soon after we set up, Lyrid meteors began painting the sky," she says. Gary Hug, Dave Costales, and Tom Hofts spent hours enjoying a multitude of deep-sky targets and making an unsuccessful visual search for Comet Shoemaker-Levy 9. Just as the astronomers were packing it up, however, they noticed a smooth blanket of light brightening the sky.

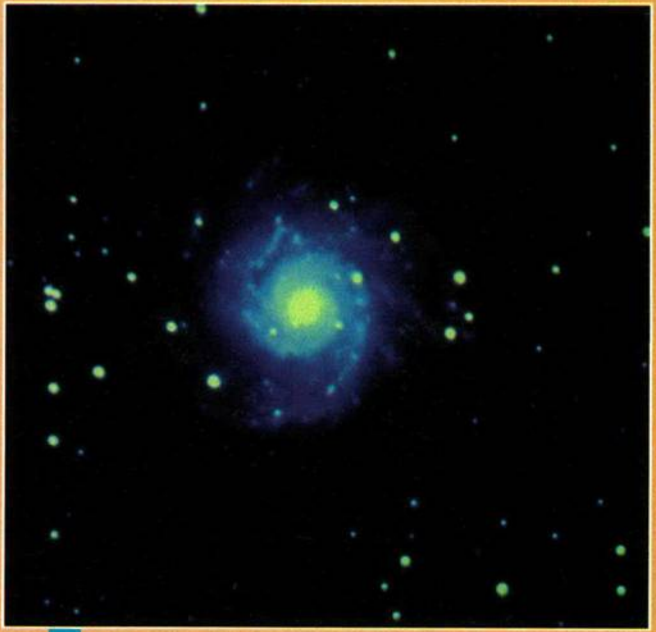
"We jumped in the truck to travel to a spot with a clear northern horizon," says Culbertson. After resettling, the observers shot several rolls of film, recording the subtle pinkish glow of the bright auroral show. "It was the first aurora I've seen in Kansas in about a year," she says. "Sometimes the greatest joys in astronomy come from things you don't expect." □

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Please label each photo with name, address, and social security number. You may send written reports via Internet to 72000.2704@CompuServe.com.

Supernova 1994I (arrow) in M51

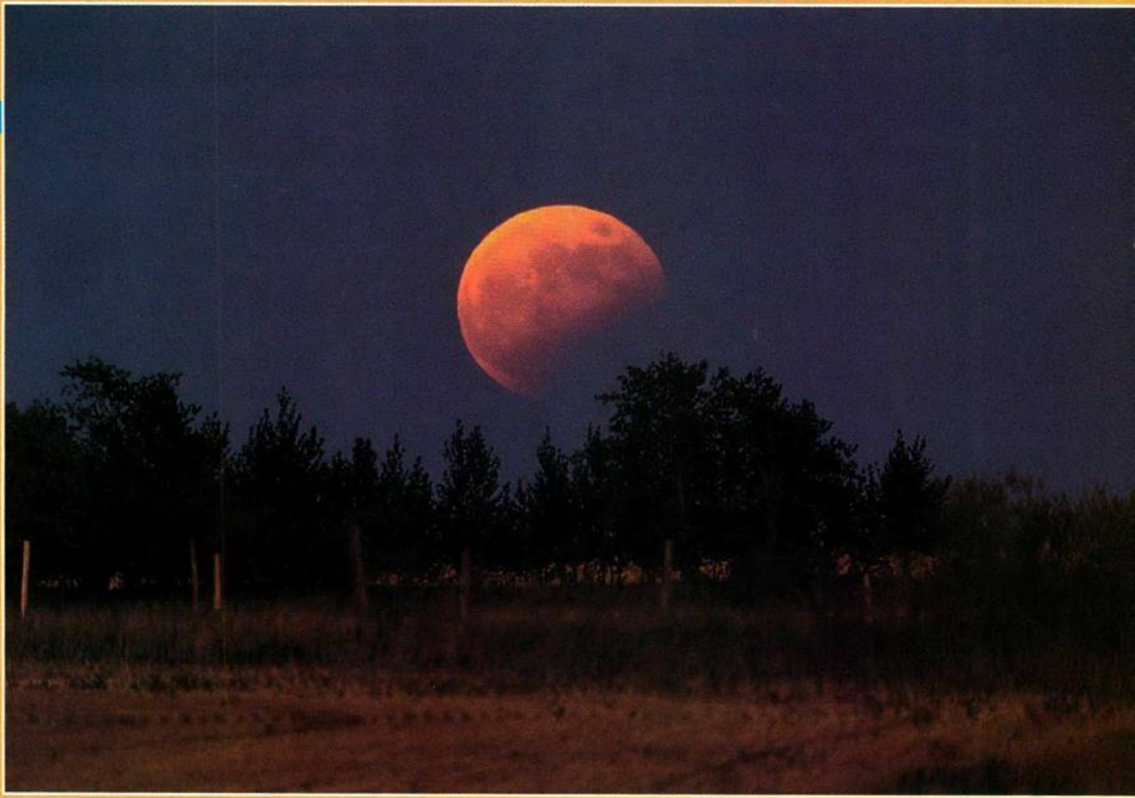
by Michael Stecker
(14-inch SCT at f/11, hypersensitized Fuji Super HG 400 film, 90-minute exposure on April 16, 1994)





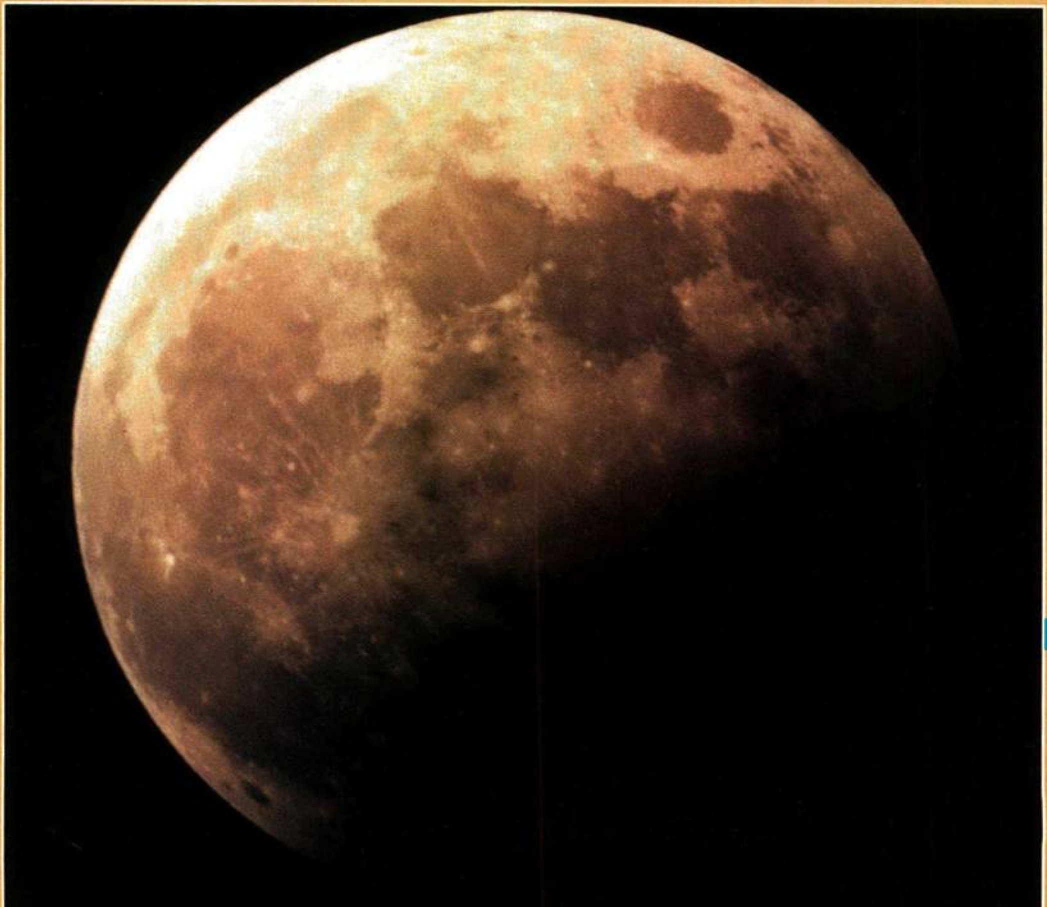
Galaxy M74 in Pisces

by Cyril Cavadore and Patrick Martinez
(12-inch f/6 reflector, Alpha 500 CCD camera, 5-minute exposure)



Moon Rising in Eclipse

by Alan Dyer
(580mm lens at f/5.8, 1/8-second exposure on Ektachrome 100 film, taken on May 24, 1994)



Earth's Shadow on the Moon

by Amy Kennet
(8-inch SCT at f/10, 1/125-second exposure on Kodacolor 400, taken on May 24, 1994)

Comet Takamizawa-Levi and the Veil

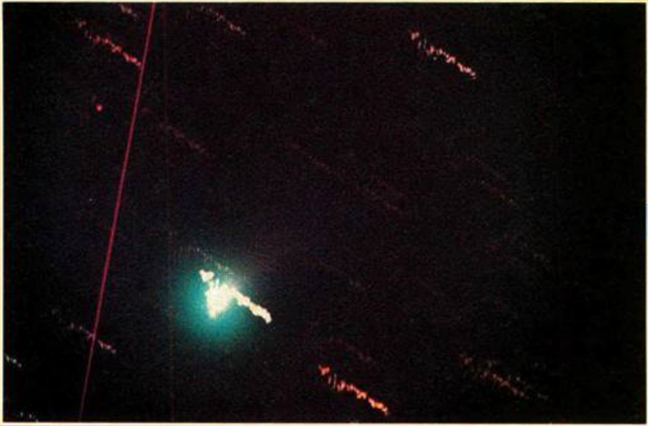
by Gerald Rhemann
(7-inch Schmidt camera,
20-minute exposure on
hypered Ektar 25 film,
taken on May 9, 1994)

Southern Milky Way Around Crux

by Ernie Piini
(50mm f/2 lens, 15-minute exposure on Konica 1600 film, taken on April 22, 1987)

STAR TRAILS DANCE OVER AN AGED TREE

Last year Mark Seibold of Troutdale, Oregon, set up his camera on a sturdy tripod, loaded it with fast color film, and exposed for several hours to capture this star trail portrait of a lonely tree (far right). Seibold's photo wins this month's $100 "Best Astrophoto" award.

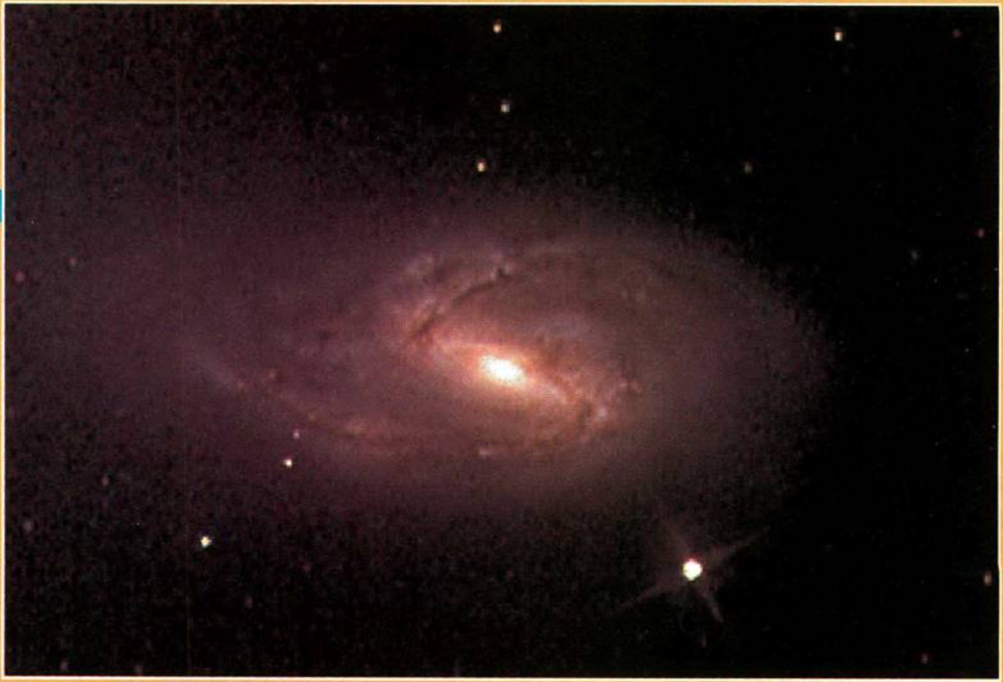


Northern Circumpolar Star Trails

by Mark Seibold

Comet McNaught-Russell

by James R. Foster
(11-inch SCT at f/6, Fuji Super HG 400 film, 43-minute exposure, taken on April 6, 1994)

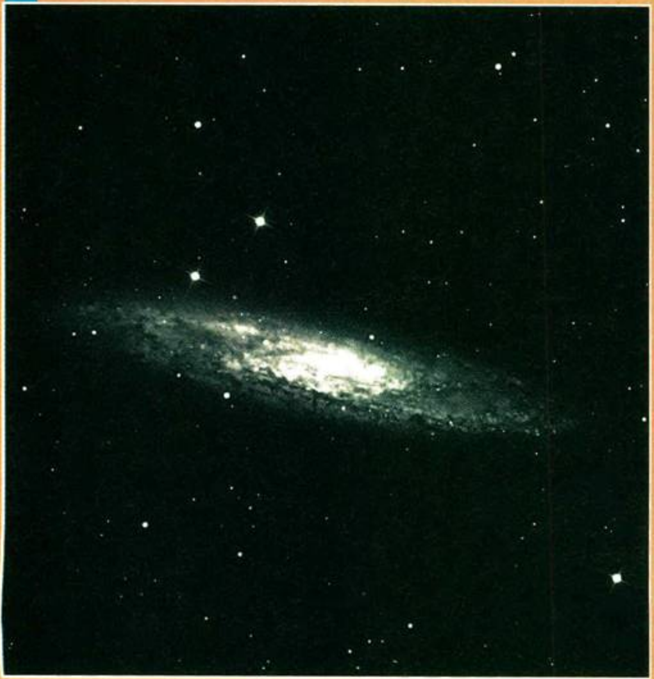


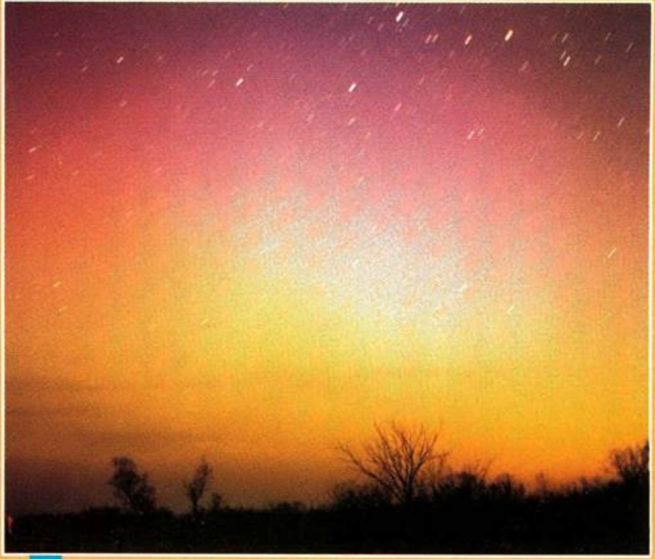
Galaxy M66 in Leo

by Jack Newton
(25-inch f/5 reflector, ST-6 CCD camera)

Galaxy NGC 253 in Sculptor

by Andrew Peters
(20-inch f/5 reflector, hypersensitized Tech Pan film, 120-minute exposure using a coma corrector)





A Pinkish Aurora over Kansas

by Brenda Culbertson
(50mm lens, 400 ISO film, taken on April 18, 1994)

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David Broad, Santa Barbara, Ca.

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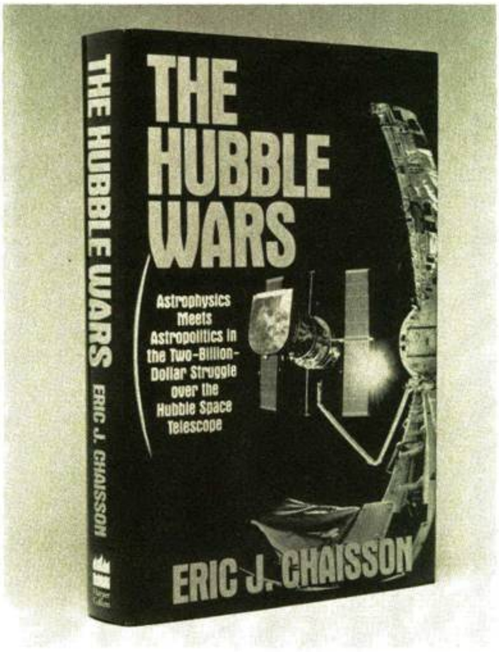
ASTRONOMY BOOKS

Hubble's Rocky Road to Success

The Hubble Wars
Eric J. Chaisson, (Harper Collins, 1994), ISBN 0-06-017114-6, 387 pages, hardcover, $27.50.

You'd have to be living on Mars not to realize that everything didn't go according to plan with the Hubble Space Telescope. First was the cost — it increased 15-fold from the time the project started in the late 1970s. Then, through no fault of its own, the telescope was launched late. Finally, after Hubble reached orbit almost a decade later than intended, program scientists and engineers discovered to their profound horror that its primary mirror was ground wrong and incapable of providing a sharp focus.


THE HUBBLE WARS
Astrophysics Meets Astropolitics in the Two-Billion-Dollar Struggle over the Hubble Space Telescope
ERIC J. CHAISSON

ASTRONOMY: Jim Forbes

These aspects of Hubble's trials and tribulations are common public knowledge. But what we, the taxpayers and interested laymen, know of Hubble barely scratches the surface of the program's history. This project was, and continues to be, a complex drama that intertwines human nature and the cold, hard realities of space engineering. Just what is the human story behind the Hubble project? Eric Chaisson's book *The Hubble Wars* gives us this story while providing a thorough overview of the telescope's technical design and use.

It turns out that Hubble's fundamental design is nothing new. For decades military and civilian intelligence agencies have flown Hubble-like spacecraft, except the optics pointed toward Earth rather than the cosmos. One reason the Perkin-Elmer Corporation was selected to grind Hubble's mirror was that the company had done similar work dozens of times under contract for the Department of Defense. Ironically, Perkin-Elmer's treading the line between the technology that was secret and that which was "safe" to use in Hubble's fabrication may have contributed to the faulty mirror. The optical stand used to test Hubble's mirror was moved, quite literally, from the "other side of the wall" to plant space the Hubble project occupied. During the stand's reassembly an error was made that, in turn, certified the flawed mirror as being ground properly.

When the primary mirror's bad shape was discovered, it came after launch and in the form of images transmitted to the ground as part of the telescope's calibration process. Star images had spidery tendrils and other odd radial structure surrounding each star's bloated disk. In a science meeting during which the flaw was announced, Chaisson describes a scene wherein everyone was ashen and silent, save for the NASA official who gagged, got up awkwardly, and trotted out of the room.

In another example of how Hubble's military roots may have contributed to a hobbled space telescope, Chaisson relates a briefing he gave spy satellite engineers. After mentioning Hubble's jittery solar panels, one person pointedly asked Chaisson why NASA was "still using those old, unwieldy panels." As it turned out, the military had long abandoned Hubble's flexible solar panel design for a more rigid type that didn't oscillate as a spacecraft moved from darkness into sunlight. Lessons learned from spy satellites weren't transferred to Hubble, ostensibly out of security concerns.

But for all its troubles, the telescope has proven a boon for astronomers. Even before last December's repair mission (which the book covers), Hubble provided outstanding data. And with its new corrective optics, the telescope should continue to be a steady source of astronomical discovery for at least another 15 years.

Big, expensive, complex projects can have rocky roads to fruition. Apollo had its fire, and the shuttle program suffered through the Challenger accident. The Hubble Space Telescope will be remembered for its discoveries rather than its bumpy start. *The Hubble Wars* is an excellent account of science history in the making and is highly recommended for anyone who is fascinated by the human side of space science. — *John Shibley*

Other Recent Releases

Looking Up: A History of the Royal Astronomical Society of Canada

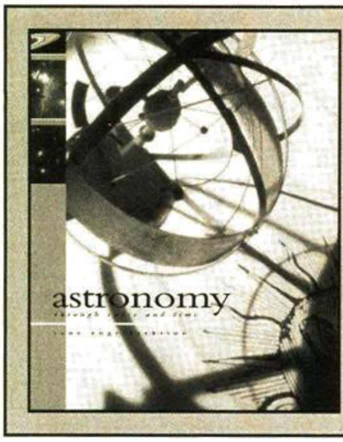
R. Peter Broughton, (Dundurn Press, 1994), ISBN 1-55002-208-3, 288 pages, hardcover, $24.95.

Through its 22 regional centers, the Royal Astronomical Society of Canada provides a strong framework for amateur activities in Canada. *Looking Up* presents an illustrated history of the Society, from its creation by eight men in 1868 to its plans to carry on into the 21st century. Chapter contents include overviews of RASC programs and publications, brief biographies of notable members and officers, and a history of its expansion west through the prairie provinces into British Columbia. Many American amateurs might not be aware of such a healthy network north of the border. *Looking Up* should serve to remedy this oversight.

The Milky Way Galaxy and Statistical Cosmology

Erich Paul, (Cambridge University Press, 1993), ISBN 0-521-35363-7, 262 pages, hardcover, $44.95.

Nineteenth-century cosmology provided for a less complex universe than ours. Astronomers assumed there was no material between stars to absorb light. Galaxies were thought to be "spiral nebulae" in our own Galaxy. Understanding the universe was simply a matter of conducting star counts and measuring spectra, positions, motions, and brightnesses. In other words, the science was mostly an exercise in statistical analysis. Cosmology today, in all its rich complexity, was born from contradictions spawned during the latter stages of this scientific era. This book traces the history of statistical astronomy and how the failure of its paradigm shaped the "new" universe of the 20th century. Astronomers who have a soft spot for history will find this an interesting book.



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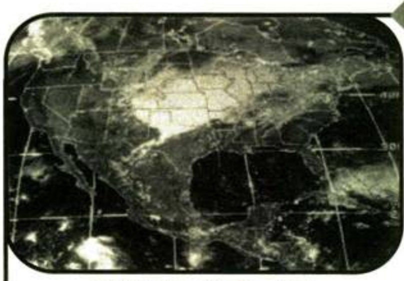

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ASTRONOMY BOOKS

The Norton History of Astronomy and Cosmology

John North, (W. W. Norton & Company, 1994), ISBN 0-393-03656-1, 600 pages, hardcover, $35; ISBN 0-393-31193-7, softcover, $18.95.

This book offers a very readable history on the evolution of cosmology and scientific astronomy, from prehistoric man through the latest theories of the universe put forth in the 1990s by physicists Zel'dovich, Penrose, and Hawking. What's refreshing about this book is that it isn't Eurocentric: It explores astronomy's rise and fall in Mesopotamia, China and Japan, pre-Columbian America, and Persia. Particularly fascinating is North's discussion of Islam's influence on the development of Western scientific thought as it applies to astronomy. If you enjoyed Daniel Boorstin's *The Discoverers* and *The Creators,* you will enjoy this history.

Practical Astronomy — A User-friendly Handbook for Skywatchers

H. Robert Mills, (Albion Publishing Limited, 1994), ISBN 1-898563-02-0, 235 pages, hardcover, $29.95.

Like it or not, some of our hobby involves math. Some aspects of astronomy might require calculus, while other equally fascinating facets can be understood with simple algebra. With this book and simple high school math, you can construct a sundial, really understand how a telescope works, calculate simple satellite orbits, or figure out Venus' distance from the Sun. All in all Mills provides over 60 projects, demonstrations, and exercises you can perform to heighten your awareness of astronomy. Looking for a good bridge between the visual and computational? This is it.

Wernher von Braun: Crusader for Space, An Illustrated Memoir

Ernest Stuhlinger and Frederick Ordway III, (Krieger Publishing Company, 1994), ISBN 0-89464-824-1, 147 pages, hardcover, $29.50.

Though intended as a companion to *A Biographical Memoir* (ISBN 0-89464-842-X, hardcover, $42.50), this book stands on its own merits, lavishly illustrated with hundreds of rarely seen photos taken during von Braun's life. The pictures trace his life from early childhood through the university (he landed a doctorate at 22), then on into his work with German rockets, through his tenure with the U.S. Army and NASA. If a picture's worth a thousand words, this book speaks volumes on Wernher von Braun's life and times. □

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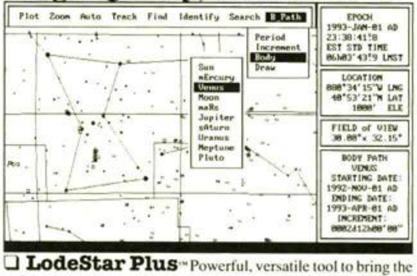

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Starfest '94 and Meteor Party, Stokesville Park Campground, Mt. Solon, Virginia. Sponsored by the Stokesville Astronomy Group. Contact Jack Wine, P.O. Box 145, Verona, VA 24482, or call the Stokesville Observatory, 800-626-3948.

August 12-13
Summer Spectacular, Lemon Lake County Park, Crown Point, Indiana. Sponsored by the Calumet Astronomical Society. Contact Stephen J. Miller, Calument Astronomical Society, (219) 845-9174.

August 13
Summer Star Party, Portsmouth Campus, Tidewater Community College, Virginia. Sponsored by the Tidewater Community College. Contact R. H. Stewart, 1064 Dune Street, Norfolk, VA 23503, (804) 583-9397.

August 30-September 4
Queensland Astrofest 1994, near Brisbane, Australia. Sponsored by the five astronomical societies in the Brisbane area. Contact Peter Adam, Queensland Astrofest, 50 Davrod Street, Roberton, Queensland 4109, Australia, call or fax (07) 345-6025.

September 2-5
Fourth Annual Huronia Star Party, Lisle, Ontario, Canada. Sponsored by the South Simcoe Amateur Astronomers. Contact Henri Van Bemmel, #1502-140 Erskine Avenue, Toronto, Ontario, M4P 1Z2 Canada, (416) 481-9937.

September 2-5
The Conjunction–Arunah Hill Weekend, Northfield Mountain Environmental Center, Northfield, Massachusetts. Contact Jack Megas, 311 Surrey Road, Springfield, MA 01118.

September 9-11
AstroFest, Camp Shaw-Waw-Nas-See, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Contact Alan Birkner, Chicago Astronomical Society, P.O. Box 596, Tinley Park, IL 60477, (708) 966-6214.

September 9-11
Fourth Annual Connecticut Star Party, Colebrook, Connecticut. Sponsored by the Astronomical Society of New Haven, Inc. Contact Joel Marks, P.O. Box 5032, Milford, CT 06460, (203) 874-4816.

September 10
Annual Telescope Meet, C. M. Crockett Park, Calverton, Virginia. Sponsored by the Northern Virginia Astronomy Club. Contact Marta Krause, 2520 Rocky Branch Road, Vienna, VA 22181, (703) 281-9049.

September 10
Island Lake Star Party, Island Lake Recreation Area, Brighton, Michigan. Co-sponsored by the Ford Amateur Astronomy Club, Precision Optics/City Camera, and other regional clubs. Call the FAAC hotline, (313) 390-5456.

September 17
Long Island Astronomy Forum, New York Institute of Technology, Greenvale, New York. Sponsored by the Astronomical Society of Long Island. Contact Ron Rizzi, (516) 795-3072.

September 17
Three Rivers AstroFest, Frick Nature Center, Pittsburgh, Pennsylvania. Sponsored by the Amateur Astronomers Association of Pittsburgh in cooperation with Pittsburgh CitiParks. Contact the AAAP c/o Wagman Observatory, (412) 224-2510.

September 23-24
8th Annual NIAGfest and Great-Con '94, Camp Crosley, North Webster, Indiana. Co-sponsored by the Northern Indiana Astronomical Group and the Great Lakes Region Astronomical League. Contact Kurt Eberhardt, 3370 E. Kenway Drive, Warsaw, IN 46580, (219) 269-6289.

September 29-October 2
4th Annual Great Plains Star Party, Kansas Flint Hills, near Kansas City, Missouri. Sponsored by the Kansas Astrophotographers and Observers Society. Contact Bob Nederman, 9200 Westbrooke Drive, Overland Park, KS 66214, (913) 888-7744.

September 30-October 1
AstroAssembly 1994, Seagrave Memorial Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. and The Astronomical Society of Rhode Island. Contact Conrad Cardano, 68 Colvintown Road, Coventry, RI 02816, (401) 828-0702. □

Submit club events four months in advance to Tracy Staedter, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Readers, please include a large, SASE with your request for information.

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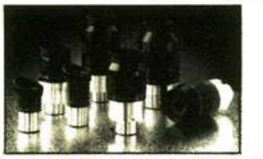

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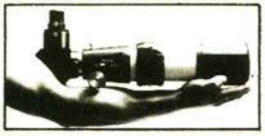

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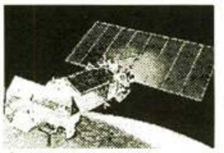

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5.6"-6.5"	97.00	72.00	127.00
6.6"-8.5"	117.00	87.00	152.00
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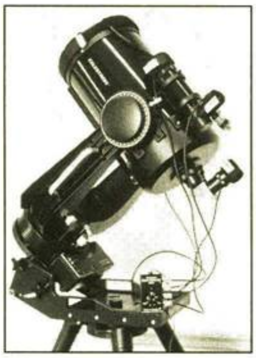

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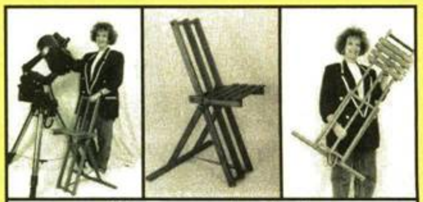

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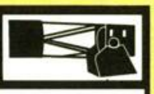

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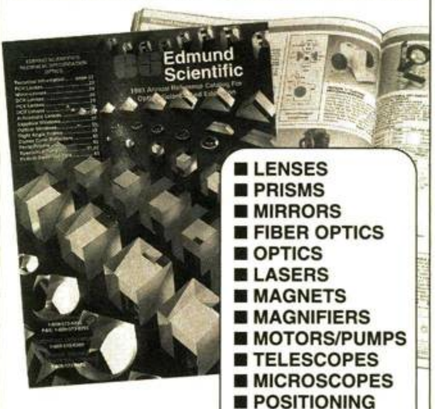

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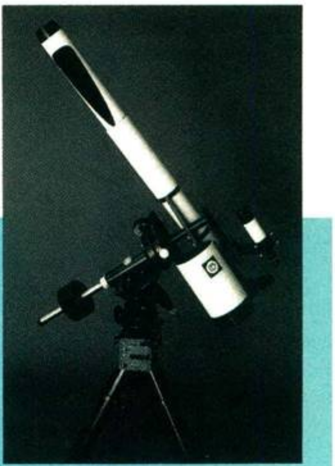

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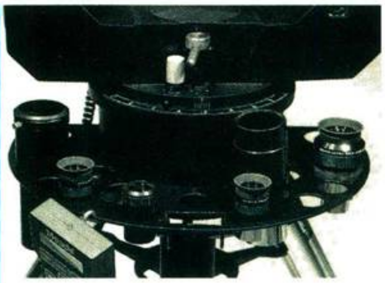

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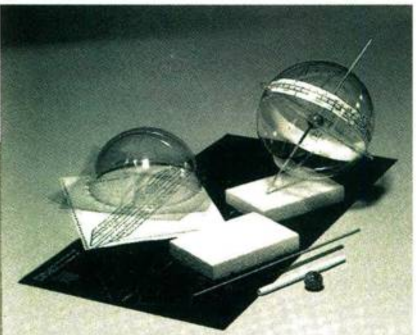

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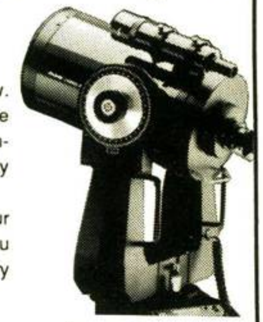

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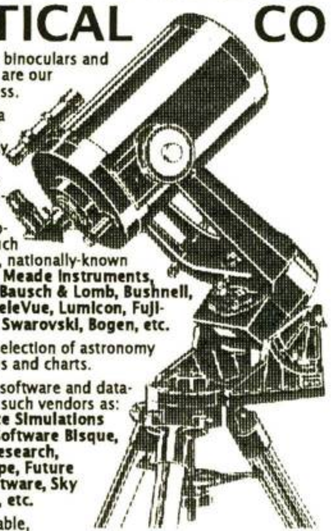

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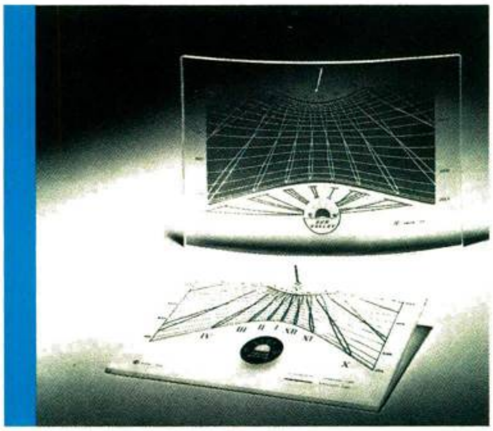
NEW PRODUCTS

Dobsonian Construction Video

Ohio amateur telescope maker James Stewart has designed a 17-inch Dobsonian that breaks down into eight pieces for easy transportation. Using an instructional video and reprint from an article that appeared in *Amateur Telescope Makers Journal*, Stewart will show you how to build a portable telescope of your own.

James A. Stewart, 314 South River St., Franklin, OH 45005. $19.95 for video and article reprint.



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Vista Company, P.O. Box 10951, Bainbridge, WA 98110, (206) 842-1093, fax: (206) 842-1793. Decal: $29.95; free-standing acrylic: $59.95. Shipping extra.

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In this latest offering from Hubbard Scientific, the planets of our solar system are reproduced in color and to scale on a 18" by 45" poster or plaque. The poster version is printed on glossy heavy paper stock, while the plaque is vacuum-formed in acrylic. Under each planet impression is information such as size and number of moons.

Hubbard Scientific, P.O. Box 760, Chippewa Falls, WI 54729-0760, (800) 323-8368, Fax: (715) 723-8021. Poster (item # T 238-P): $15; plaque (T 238): $130.

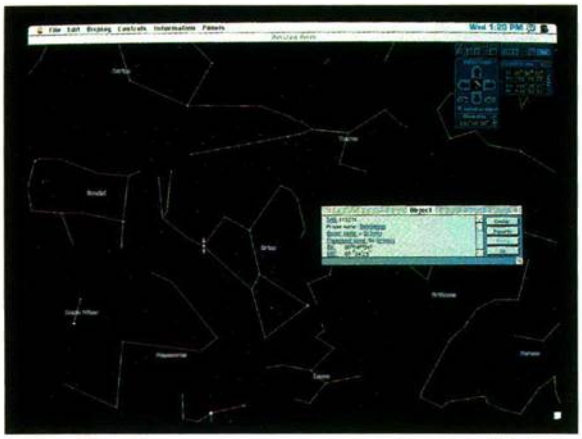
This department presents new product announcements issued by their manufacturers. Product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers should send their product announcements to the attention of John Shibley.

ASTROBYTES

Multimedia Planetarium

RedShift (1.0)
Maris Multimedia Ltd., 99 Mansell Street, London E1 8AX, England. In the United States, call (800) 336-0185; from overseas and Europe call (44) 71 488 1566. Price: $99. Minimum requirements: 80386SX-based computer, 4 MB of memory, Windows 3.1, mouse, Super VGA display (800x600 mode recommended), 1.5 MB of hard disk space, and a CD-ROM drive; or a Macintosh LC computer (IIci recommended), 4 MB of memory (5 MB recommended), 1.5 MB of hard disk space, System 7.0, color display, and a CD-ROM drive. Maris is releasing also a PowerPC version (written in native code).

RedShift is a multimedia planetarium-type program you'll really enjoy exploring. Its jam-packed CD-ROM contains almost 600 MB of files, including lots of catalogs, an illustrated (and animated) dictionary, more than 700 photos of astronomical objects, six movies, and maps of Earth, the Moon, and Mars. Beginners will like the easy-to-use control panels and friendly manual, while advanced amateurs will find the databases rich enough to suit most of their needs.



ASTRONOMY: Chris Becker

The program plots star charts and horizon views of the sky using a database of 250,000 stars. It can display the sky for any date between 4712 B.C. to A.D. 11,000 and can show fields of view ranging from the entire sky down to 1' across. It shows all nine planets, 35 satellites of the planets, almost 100 comets, 5,011 asteroids, and over 40,000 deep-sky objects. A "filter" dialog turns objects within these databases on and off. For example, it can display only elliptical galaxies or only spirals, or bright, dark, or planetary nebulae. A clever invert switch turns off selected items and displays everything not selected previously.

The star filter selects stars by magnitude, spectral type, and luminosity class. (For fun, try plotting the locations of just the type Ia and Ib supergiant stars in an all-sky map.) It also sets labels by common name and Bayer and Flamsteed designations, as well as number in the Smithsonian Astrophysical Observatory catalog, Yale *Bright Star Catalog*, or FK5 fundamental catalog.

The asteroid filter displays asteroids by size, orbital eccentricity (ellipticity), or group, such as the Earth-approaching Apollos or the asteroids that cross Mars' orbit. The planet filter selects whether an icon, disk, or image displays each planet's position. A slider sets the size for the planet image and buttons turn atmospheres, rings, and labels on and off.

RedShift also prints a series of visibility reports for the planets. These provide tables and graphical displays of a planet's diameter, magnitude, illumination, rise and set times, altitude throughout the day, distance from the Moon in the sky, distance from the Sun in the sky and in space, and distance from the observer.

A series of control panels similar to those on a VCR set the observer's location, time and date, zoom factor, and objects displayed. Other panels allow moving around the sky, stepping forward and back in time, circling around a planet, and tracking a planet's motion from six different points of view. Yet another panel called the "Movie Recorder" creates an animated view of any celestial event for replay at any time. These control panels and the filter dialog boxes are so fundamental to the use of *RedShift* that the developers organized the manual around these controls.

As expected, clicking on an object brings up an identification box that provides the object's name, position, magnitude, distance, and other pertinent information. A button displays any images of the object contained on the CD-ROM. To view just the images, select the "Photo Gallery" from one of the menus, and choose between the hundreds of photos at leisure. Choose the "Movie Gallery" to view six movies

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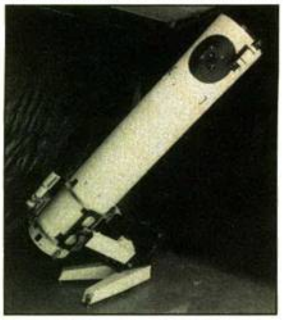

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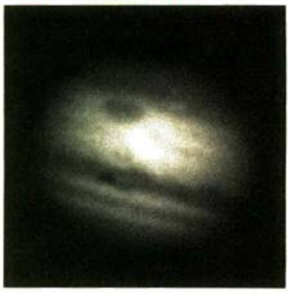

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(Note: The image that appeared in the April Astronomy advertisement was, through Astronomy's production error, degraded in quality.)

taken by Apollo astronauts while landing, exploring the Moon's surface, and taking off.

A feature many astronomers will appreciate is the Penguin *Dictionary of Astronomy* by Jacqueline Mitton. The dictionary contains illustrations, 23 of which are animated to show how telescope mounts turn, light passes through different scopes, and eclipsing binary stars brighten and fade as the stars orbit each other.

RedShift also includes maps of Earth, the Moon, and Mars that allow zooming in and out and viewing from different angles. Labels identify many of the larger, more important features, and an optional grid shows latitude and longitude.

The program doesn't display the outline of the Milky Way, nor will it allow changing type size and style or the colors of constellation lines and labels. Deep-sky observers unfortunately can't invert or mirror star charts printed by the program for easier use at the eyepiece. Galactic coordinates would be a nice addition to the horizon and equatorial coordinate maps already produced.

These few quibbles don't detract from the marvelous job Maris has done in assembling a truly multimedia planetarium-type program. The price is excellent considering the databases, photos, and dictionary. Maris will make users and distributors happy by producing the Mac, Power PC, and Windows versions on the same CD-ROM in the future; that way, viewers can use the program on whichever computer they have available. Beginning astronomers will really enjoy exploring the many features of *RedShift*, and the depth of the program's features will keep more advanced astronomers happy as well.
— *Dave Bruning*

NEW SOFTWARE

Sky Survey on CD-ROM

Astronomical Society of the Pacific, Dept. 10x, 390 Ashton Avenue, San Francisco, CA 94112-1787, (415) 337-2624. Price: $3500.

The sky survey images that were used to create the Hubble Guide Star Catalog are now available as compressed images on 101 CD-ROMs. To save file space, the developers of the CD-ROMs compressed each image by a factor of 10. The compressed images are virtually indistinguishable from the originals and yield identical positional and brightness information. The 61 CD-ROMS of the southern sky survey will be available in 1994 and the 40 CD-ROMs of the northern survey in 1995. Separate purchase of the southern and northern surveys is not possible. The CD-ROMs contain software for UNIX- and VMS-based computer systems for decompressing the images.

Dance of the Planets, Q.E.D. (2.7)

ARC Science Simulation Software, P.O. Box 1955, Loveland, CO 80539, (303) 663-3223, fax (303) 667-1105. Price: $195. Minimum requirements: 80286-based computer, math coprocessor, 580 KB of free memory, DOS 5.0, 1.2 MB of hard disk space, and VGA display. Optional Stars 8.0 (total of 45,000 stars) database extension: $35; Stars 10+ database (total of 400,000 stars) also available.

Query, Explore, and Demonstrate is the purpose of this extended version of *Dance of the Planets*. (For a review of *Dance*, see the May 1992 ASTRONOMY.) Star symbols can represent spectral type instead of apparent brightness. "Starbias" is a new command that permits adjustment of the display to enhance viewing of faint stars and low-contrast features on planets. *Q.E.D.* has greater flexibility than *Dance* for adding elements describing the orbits of asteroids, comets, and satellites and for printing the results of orbital calculations. An "event recorder" stores information about comet and spacecraft encounters with planets, enabling the later perusal of dates and positions for objects that have multiple encounters with a planet. (The display screen shows information only about one encounter at a time, overwriting previous data.)

With *Dance*, a "resume" file lets a user store the frames of a simulation for viewing at a later time. *Q.E.D.* can chain up to 10 of the resume files together for display as an ordered group, which is useful for demonstrations and presentations.

Previously available as a separate extension, the *Observer's Companion* now comes with *Q.E.D.* This almanac package determines eclipse dates and paths, conjunctions and oppositions, and planetary data such as distance, diameter, sunlit percentage, and position for the dates of the stationary points, aphelia, and perihelia.

Vistapro for the Macintosh and Windows

Virtual Reality Laboratories, 2341 Ganador Court, San Luis Obispo, CA 93401, (805) 545-8515, fax (805) 781-2259. Price: $129.95 for either version. Minimum requirements: 80386-based computer, Windows 3.1, a mouse, 4 MB of memory, 4 MB of hard disk space, and VGA display (up to 1280x1024 resolution); or Macintosh SE, System 7.X, 4 MB of free memory, 4 MB of hard disk space, and a color monitor.

Vistapro is a landscape generating program that translates digital elevation data files into 3-D images of actual landscapes (see the review of the DOS version in the June 1992 ASTRONOMY.) In addition to many Earth-based landscapes such as Yosemite Valley and the Grand Canyon, users can "visit" the giant volcano Olympus Mons or the Mariner Valley, both on Mars. The program can generate left- and right-hand images for stereo viewing and create image files for use with other programs.

Optics Lab

Science Lab Software, 93 Albemarle Road, Norwood, MA 02062, (617) 769-5153. Price: $79. Minimum requirements: 80386SX-based computer, Windows 3.1, a mouse, and 644 KB of hard disk space.

Reading books to learn how a telescope works can be dull. Instead, try an optical ray-tracing program that shows how lenses and mirrors focus light in a scope. Using different-colored light rays demonstrates how chromatic aberration occurs. Viewing the focus off the central axis of the scope shows how some scopes create coma and astigmatism.

Optics Lab makes the study of optics easy by using pull-down menus to select an optical element. Moving an optic is easy: Just place the mouse cursor on the element, hold down the left button, and drag the element to its new location. The program keeps track of up to 100 optics at a time, which can include prisms, lenses, mirrors, beam splitters, flat glass, aperture stops, and observing screens. It displays not only the light ray paths but also a spot diagram, wavefront, and point spread function for evaluating the final image quality.

CircumSpace (1.0)

KlassM Software, 284 142nd Avenue, Caledonia, MI 49316, fax or call (616) 891-4049. Price: $15 (shareware). Minimum requirements: IBM PC-compatible computer, 640 KB of memory, a mouse, and EGA display. Recommended: 80386-based computer.

Travel to the nearest stars using *CircumSpace*. The database contains distances and positions of almost 7,780 stars, allowing views of the Sun's neighborhood from any position out to 25,000 light-years from Earth. A mouse click on a star brings up a box identifying it and giving its distance and apparent brightness as seen from the current location and from Earth.

A display constantly indicates which stars are closest to the present location. Keyboard commands permit jumping to the nearest star or to the edge of the surveyed volume (25,000 light-years from the Sun). Instead of jumping to particular stars, owners of an 80386-based computer can travel among the stars to view the Sun's neighborhood. ☐

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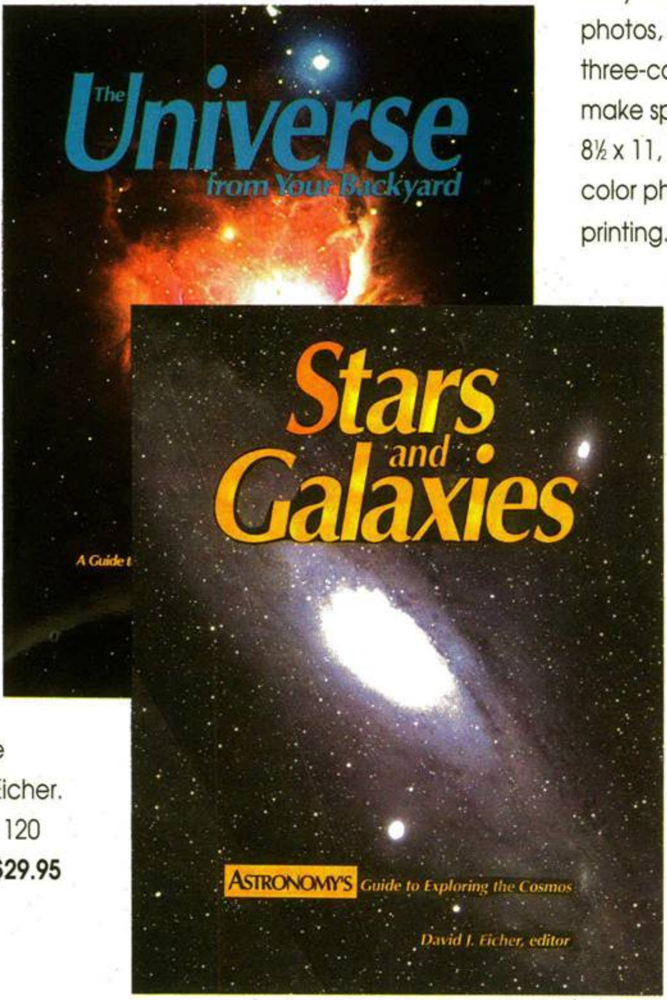
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READINGS & CREDITS

Stellar Oddballs (page 50)

Stars by James B. Kaler, (Scientific American Library, 1992). Describes the nature of ordinary stars and their oddball cousins.

Guiding Gremlins (page 70)

A Manual of Advanced Celestial Photography, by Brad D. Wallis and Robert W. Provin, (Cambridge University Press, 1988). Offers tips on guiding and building a flexure-free astrophoto system.

Seeing & Believing (page 76)

Observing and Photographing the Solar System, by Thomas Dobbins, Donald Parker and Charles Capen, (Willmann-Bell, 1988). Provides overview of planetary observing and photography techniques.

Annulus Americanus (page 80)

Chasing the Shadow, by Richard Talcott and Joel Harris, (Kalmbach, 1994). Notices where and when solar eclipses occur into the next century and suggests how to observe and photograph them.

Cover: Alberto Levy; **p. 4, top:** Clementine Science Team/NASA; **left:** Frank Zullo; **right:** Jean Dragesco; **p. 5:** Don Parker; **p. 18, top:** Holland Ford (STScI/JHU), NASA, et al.; **bottom:** Chris Burrows (ESA/STScI) and NASA; **p. 20, top:** Massimo Ramella/Observatorio Astronomico, Trieste; **bottom:** NASA; **p. 22:** John Shibley; **p. 26, top:** NASA/JPL; **bottom:** Michael Kilker, Markus Kissler, and Tom Richtler/ ESO; **p. 27, top:** University of Texas; **bottom:** Emilio Flaco, Center for Astrophysics; **p. 30, top:** the Johns Hopkins Univeristy Applied Physics Laboratory; **bottom:** P. Challis, O. Kuhn, and B. Schmidt/Harvard-Smithsonian Center for Astrophysics; **pp. 32-33:** Michael Carroll; **p. 34:** Brian Tkachyk; **bottom:** NASA/Hubble Space Telescope; **pp. 36-37:** Phil Kirchmeier; **p. 38:** George Greaney and Mike Newton; **p. 39:** Jack Newton; **p. 42, left:** Clementine Science Team/USGS; **top:** NRL; **bottom:** ACT Corporation; **pp. 43-46:** Clementine Science Team/USGS; **p. 47, top and right:** NRL; **bottom:** LPI; **p. 50:** Ron Miller; **p. 51:** Kenneth Paul Fye, 50mm f/2 lens, 11-minute exposure on Ektachrome 400 film; **p. 52, top:** George Herbig; **bottom:** George Jacoby, NOAO; **p. 53, top:** Ron Miller; **bottom:** Robert Hjellming, NRAO; **p. 54:** Ron Miller; **p. 55:** Jan van Paradijs/William Herschel Telescope; **p. 60:** Jean Dragesco; **p. 61:** Alfred Lilgew; **p. 62:** Dewey Vanderhoff; **p. 63:** Keith Ward; **p. 65:** Glen Deen; **p. 68:** Victor Rogus; **p. 69:** Jean Dragesco; **p. 70:** Alan Dyer, M8/M20 area; 105mm apochromatic refractor at f/4.5, 15 minutes, ScotchChrome 400 film pushed to ISO 800, photographed from Las Campanas, Chile; **p. 71, top:** Alan Dyer; **bottom:** Chris Becker; **pp. 72-74:** Alan Dyer; **p. 75:** Alan Dyer, 105mm apochromatic refractor at f/4.5, 20 minutes, ScotchChrome 400 film pushed to ISO 800, photographed from Las Campanas, Chile; **pp. 77-79:** Donald Parker, 16-inch f/5 reflector working at f/48 and Spectra Source Lynxx CCD camera; **p. 80, top:** Vic Winter, 10-inch f/10 SCT, Type II glass filter, 1/250th second, Fujichrome 100, images combined in Adobe Photoshop; **middle:** Mark Goulet, 55mm lens set to f/16, shot at 1/1000 second, Ektar 100 print film; **pp. 80-81:** Alan Dyer, 4-inch refractor working as a 1500mm f/15 telephoto, 1/500 of a second, Ektachrome 100; **p. 82:** Dan Schechter, 45mm lens, 1/60 second taken 6 minutes apart, mylar solar filter, Ektar 100 print film; **pp. 82-83:** Robert Stephens, 5-inch f/10 SCT working with a 2x teleconverter, glass solar filter, 1/4 of a second, Kodachrome 200; **p. 83, middle left:** John Shibley, 35mm lens at f/8, 1/60 second, Kodak Gold 200 print film; **middle, right:** John Shibley, 180mm lens at f/8, 1/250 second, Kodak Gold 200 print film; **bottom:** Ronald Royer, 50mm lens, slide film; **p. 84:** Rick Shanahan, 50mm lens at f/16, 1/125 second, Kodacolor 200 print film; **p. 85:** Michael Maunder, 1200mm f/16, 1/60th second exposure on ASA 50 Velvia slide film at 10-minute intervals using a neutral-density #3 filter; **p. 87, top:** Michael Stecker, 14-inch SCT at f/11, hypersensitized Fuji Super HG 400 film, 90-minute exposure on April 16, 1994; **bottom:** Cyril Cavadore and Patrick Martinez, 12-inch f/6 reflector, Alpha 500 CCD camera, 5-minute exposure; **p. 88, top:** Alan Dyer, 580mm lens at f/5.8, Ektachrome 100 film, 1/8-second exposure on May 24, 1994; **bottom:** Amy Kennet, 8-inch SCT at f/10, Kodacolor 400 film, 1/125-second exposure on May 24, 1994; **p. 89, top:** Gerald Rhemann, 7-inch Schmidt camera, hypersensitized Ektar 25 film, 20-minute exposure on May 9, 1994; **bottom:** Ernie Piini, 50mm lens at f/2, Konica 1600 film, 15-minute exposure; **p. 90, top:** James R. Foster, 11-inch SCT at f/6, Fuji Super HG 400 film, 43-minute exposure on April 6, 1994; **middle:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **bottom left:** Andrew Peters, 20-inch f/5 reflector, hypersensitized Tech Pan film, 120-minute exposure using a coma corrector; **bottom right:** Brenda Culbertson **p. 91:** Mark Seibold; **p. 92:** Jim Forbes; **p. 105:** Chris Becker; **p. 114:** Jim Barclay. ☐

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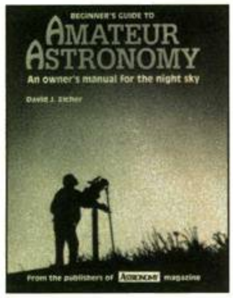
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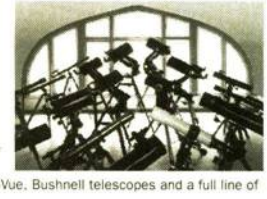

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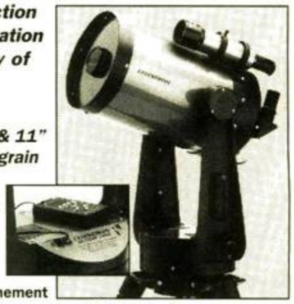

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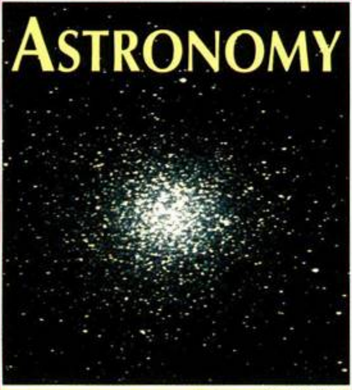

Jim Barclay

WHERE HAVE ALL THE BLACK HOLES GONE? They're everywhere, astronomers used to say. But no more. Despite extensive searches, they've found only three promising stellar candidates.

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SOUTHERN SKY WONDERS Australian Jim Barclay leads a tour of Omega Centauri (above), Eta Carinae, the Coal Sack, and other grand sights visible "down under."

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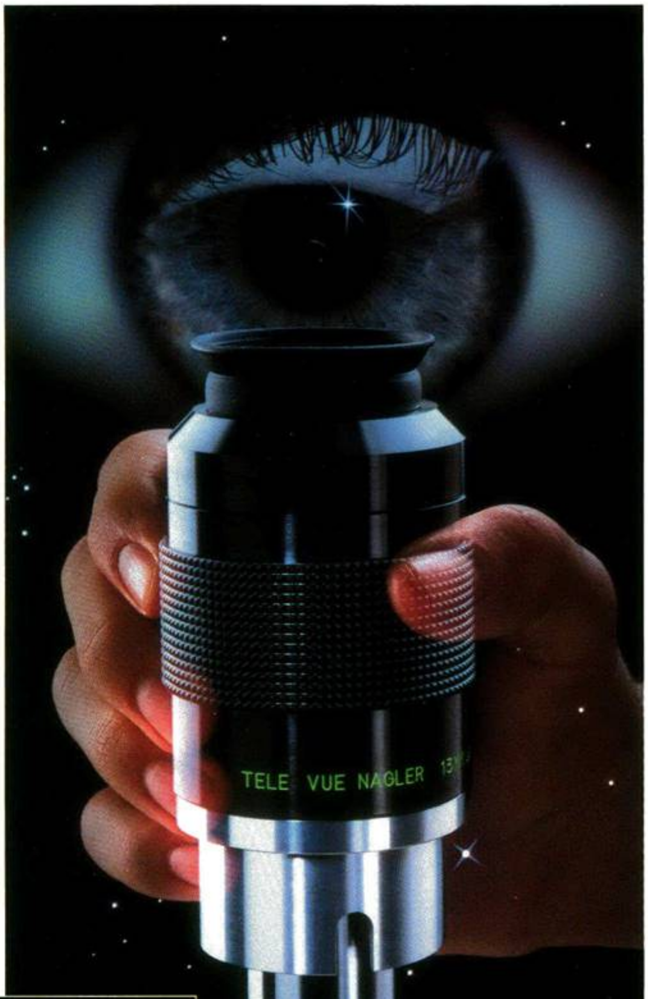
"NO OTHER EYEPIECES...SATISFY ME NOW."

— The following unsolicited letter from a fellow enthusiast is dated Mar. 30, 1994. It is printed unedited and with permission.

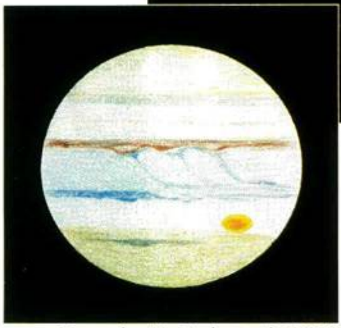


Dear Mr. Nagler,

"I thought it long overdue that I write to give my impressions of your Nagler eyepiece designs. *I say 'long overdue,' because I bought my first Nagler (a 7mm) back in 1984. The reason for the purchase was that earlier that year I had invested in a Celestron C-11 and a 4" Fluorite, F/9 refractor. I thought that the stated objectives of the Nagler design — long eye-relief and a wide, highly corrected field of view, would exploit the full potential of a telescope with 2,800mm focal length, and the imaging capacities of a fine refractor. I was not disappointed. Soon after came the fantastic 9mm and 11mm Naglers and then the 4.8mm for the refractor.*

These eyepieces have given me my most rewarding hours spent at the telescope. *My main interest is in the planets which I draw and give lectures on at our local school and observatory. The observation of the planets requires painstaking hours spent at the eyepiece. The Naglers suit my purposes exactly.*

When the Type 2s were introduced onto the market I could not resist them. I purchased the 16mm and 12mm models. The 20mm seemed too large, heavy and costly, so I left it alone. These were the same reasons for not buying the 13mm (apart from the fact that by then I owned a 12mm Type 2). However, earlier this year, after years of looking through other people's 13mm and 20mm Naglers, I finally decided to take the plunge myself. ***So now I own a full set of Naglers*** *(including the wonderful 11mm which despite many offers, I will not part with).*



Drawn by Mr. Toohey with 12 N2

When I remember what eyepieces for the amateur market were like before the introduction of the Naglers (like looking down a drain pipe, or 60° fields, with astigmatism and severe edge of field aberrations), ***it is clear that your designs have taken us a quantum leap forward. No other eyepieces, in the Naglers' range of focal lengths, satisfy me now.***

Many of my fellow planetary observers say that conventional field eyepieces are sufficient. In a way they are right; good Plössls, for example, produce superb images. However, I believe the extra eye-relief, the huge field of the Naglers, coupled with marvellous image correction and the impression that ***the telescope simply gets out of the way,*** *all add up to a delightful psychological difference when using the Naglers. One feels more involved, more present to what one is viewing.*

Over the years I have found that amateur astronomers can be fairly stubbourn people in somehow defending their choice of equipment. Next thing you know they upgrade what was once, in their view, the very best available. ***Only good products stand the test of time. For me, the Naglers are such a product.*** *Not only have they remained with me; I have kept buying more of them!*

To some extent, astronomy, and particularly amateur astronomy, is about emotion and the involvement of the imagination. ***I have to say that Nagler eyepieces have captured my imagination.*** *As well as giving pride of ownership, Naglers are immensely satisfying and a joy to use.*

The little instruction sheet that comes with the eyepieces says that you wish the user 'years of exciting viewing with these eyepieces, and welcome comments on your experiences with them.' So you asked for it. After a decade of superb images (many of which remain etched on my memory; most of which I have recorded on paper) I felt it timely to share my comments and to thank you for your contribution to amateur astronomy."

Yours Sincerely.
Christopher A Toohey

Christopher Toohey, Australia

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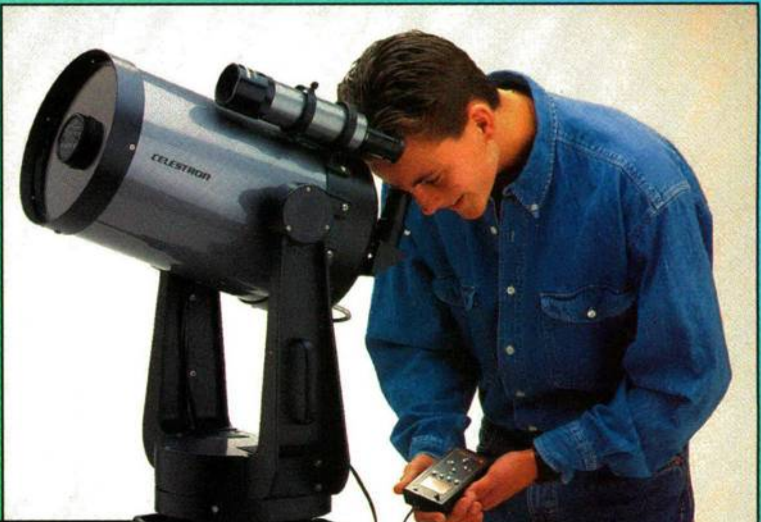

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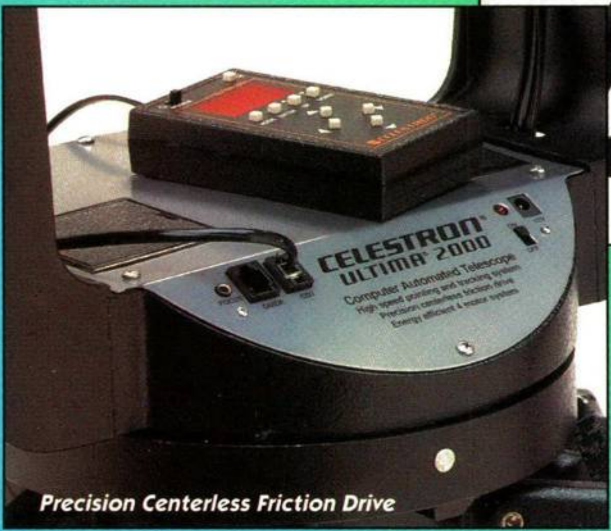
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